# STEAM BOILERS

D·M·DILLON
STEAM BOILER WORKS
FITCHBURG, MASS.

ESTABLISHED 1870
INCORPORATED 1906

# D. M. DILLON STEAM BOILER WORKS

MANUFACTURERS OF

MANNING, PLAIN UPRIGHT, LOCOMOTIVE, MARINE, HORIZONTAL

# STEAM BOILERS

TANKS, PENSTOCKS, BLEACHING KIERS, FILTERS, DIGESTERS, SMOKE-STACKS, SMOKE-FLUES, AND PLATE IRON WORK

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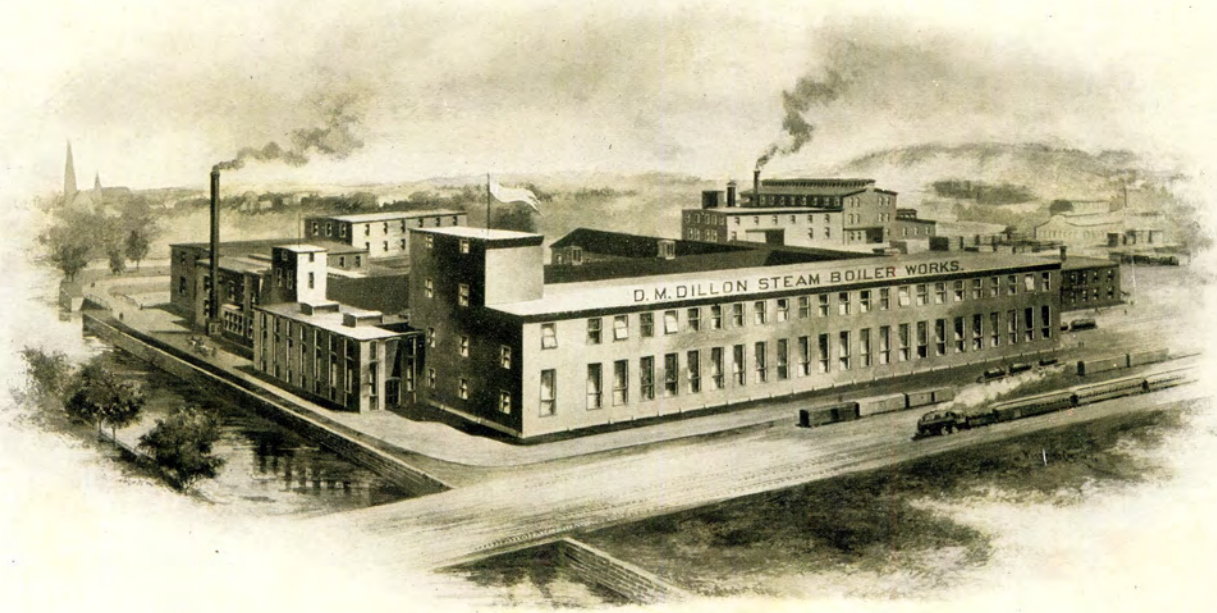


PLANT OF THE D. M. DILLON STEAM BOILER WORKS,
FITCHBURG, MASS., U. S. A.

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# INDEX


| | Page |
|---|---|
| Battery of horizontal return tubular boilers, flush fronts, | 15 |
| Battery of horizontal return tubular boilers, overhanging fronts, | 14 |
| Battery of Manning boilers, | 40 |
| Boiler explosions, | 63 |
| Brackets for horizontal return tubular boilers, | 19 |
| Butt joints, | 48, 49 |
| Care of boilers, | 61 |
| Chimneys, steel, | 18 |
| Chimneys, sizes of | 60 |
| Crowfoot bracing, | 13 |
| Domes, description of | 17 |
| Domes, size and location of | 29, 31 |
| Dutch oven, | 17 |
| Equation of pipes, | 58 |
| Explosions of water tube boilers, | 63 |
| Extension fronts, | 17 |
| Feed water, impurities in, | 55 |
| Firebrick mouthpieces, | 19 |
| Fire doors for Manning boilers, | 41 |
| Fire door, weighted, | 16 |
| Flanges for pipe connections, | 41 |
| Flanges, size and drilling of, | 59 |
| Flush fronts, | 11, 31 |
| Fronts, cast-iron, | 10, 11 |
| Fronts, steel, | 16 |
| Grate surface horizontal return tubular boilers, | 23 |
| Handholes for cleaning crown sheet, | 39 |
| Hangers for horizontal return tubular boilers, | 19 |
| Heating of buildings, | 56 |
| Horizontal return tubular boilers— | |
| Battery of flush fronts, | 15 |
| Battery of overhanging fronts, | 14 |
| Description of | 6 |
| Methods of suspending | 20, 21, 22 |
| Setting of flush front, | 11, 31 |
| Setting of overhanging front, | 10, 29 |
| Sizes of | 23 |
| Tests of | 9 |
| Three course (275 h.p.), | 12 |
| Two course (325 h.p.), | 12 |
| Horse power of boilers, definition of, | 50 |
| Horizontal return tubular boilers, | 23 |
| Internal furnace boilers, | 45 |
| Locomotive boilers, | 44 |
| Manning boilers, | 42 |
| Large vertical boilers, | 42 |
| Small vertical boilers, | 43 |
| Internal furnace boilers, | 45 |
| Joints, butt, | 48, 49 |
| Joints, lap | 47 |
| Kier, | 46 |
| Lap joints, | 47 |
| Locomotive boiler, | 44 |
| Longitudinal bracing, | 13 |
| Manning boiler, single, | 38 |
| Battery of | 40 |
| Cast-iron base, | 38 |
| Description of | 34 |
| Dimensions of | 42 |
| Ogee ring, | 38 |
| Tests of | 37 |
| Marine (internal furnace) boiler | 45 |
| Ogee ring, | 38 |
| Overhanging fronts, | 10, 29 |
| Pipe equations, | 58 |
| Pipe flanges, | 59 |
| Plain upright boilers, dimensions of | 42 |
| General view, | 39 |
| Reverse flange, | 38 |
| Riveted joints, | 47 |
| Rules for care of boilers, | 61 |
| Saddle, steam pipe, | 41 |
| Scotch (internal furnace) boiler, | 45 |
| Setting for flush front boilers, | 30, 31 |
| Setting for overhanging front boilers, | 28, 29 |
| Stacks, | 18, 60 |
| Steam, saturated, | 52 |
| Steam, superheated, | 53 |
| Suspension brackets, | 19 |
| Suspension frames, | 20, 21, 22 |
| Suspension frames, table of | 32, 33 |
| Table of— | |
| Boiler tubes, | 58 |
| Equation of pipes, | 58 |
| Flush fronts, | 31 |
| Horse power of horizontal return tubular boilers, | 23 |
| Internal furncae boilers, | 45 |
| Locomotive boilers, | 44 |
| Manning boilers, | 42 |
| Overhanging fronts, | 29 |
| Plain upright boilers, | 42 |
| Small vertical boilers, | 43 |
| Saturated steam, | 52 |
| Standard pipe flanges, | 59 |
| Suspension frames, | 33 |
| Tanks, pressure, | 46 |
| Tanks, size and capacity of | 57 |
| Tests of horizontal return tubular boilers, | 9 |
| Tests of Manning boilers, | 37 |
| Through rods (bracing), | 13 |
| Tubes, table of | 58 |
| Twin base, | 41 |
| Upright boilers, large, | 39 |
| Upright boilers, large, table of | 42 |
| Upright boilers, small, | 43 |
| Useful information | 62 |
| Vertical boilers, large | 39 |
| Vertical boilers, large, table of | 42 |
| Vertical boilers, small, | 43 |
| Water tube boilers, explosions of | 63 |
| Y for safety valve | 41 |

# Introductory

WE take pleasure in presenting to the trade our catalogue number five, and respectfully call your attention to its contents. As manufacturers of various types of boilers for a long term of years, we have been enabled to experiment extensively, and, as a result, have compiled the following list of essential points, and we recommend their careful consideration by those contemplating the installation of power and heating plants:

1. Cost of installation.
2. Economy of fuel.
3. Circulation.
4. Cleaning fire surfaces.
5. Cleaning water surfaces.
6. Cost of maintenance,
7. Open market for renewal parts.
8. Accessibility for inspection.
9. Accessibility for repairs.
10. Rapid steaming and responsive qualities.
11. Constant economy.
12. Durability.
13. Safety of boiler.
14. Safety of tubes.
15. Simplicity.
16. Baffle-plates.
17. Highest workmanship.
18. Return on investment.
19. Reliability.
20. Effective heating surface.
21. Boring of tubes.
22. Short circuiting of gases.
23. Type of boiler best suited for bad feed water.
24. Ease of temporary repairs.
25. Economy of floor space.
26. Ability to furnish dry steam.
27. Ability to stand forcing without serious loss in economy.
28. Ratio of heating surface to grate surface.
29. Ratio of water space to steam space.
30. Per cent. of air space in grates.

From intending purchasers, and others who are interested, we solicit a careful examination of the following pages, which describe in detail our various productions. We are also manufacturers of specialties along the lines of boiler construction, and would be pleased to receive inquiries concerning same.

# Horizontal Return Tubular Boilers

THERE has been a tendency in the past, principally, we think, among those not versed in the fundamental principles of steam, to accept as a fact the superiority of water tube over fire tube boilers. This is regrettable because it leads to an expenditure for boilers almost double that required for the common horizontal tubular type, which is far better, we believe, from every standpoint. Water tube boilers are purchased with various objects in view, scarcely one of which is ever realized, and we consider that it will be a misfortune for boiler users not to come to a better understanding of the advantages to be derived from the use of the horizontal tubular boilers.

It was thought by many that the thick plates necessary for high pressure with this type of boiler were a source of danger, on account of the liability of overheating. An examination of the theory of transmission of heat through steel plates will show that their capacity to transmit heat is scarcely affected by any probable thickness that may be used. This fact has been known for many years, and Prof. Rankine has written: "The external thermal resistance of the metal plates of boiler flues and tubes, and other apparatus used for heating and cooling fluids, is so much greater than the internal thermal resistance that the latter is inappreciable in comparison; and consequently the nature and thickness of those plates have no appreciable effect on the rate of conduction through them." Rankine also states that the results of evaporative tests on boilers justify the disregard of the effect of thickness on the rate of transfer of heat.

Mr. Isherwood, another celebrated engineer, made a series of experiments on the transmission of heat through plates varying from $\frac{1}{8}''$ to $\frac{3}{8}''$, a variation of 200% in thickness, when one side was exposed to steam and the other to water, and he found the difference in thickness of plates did not measurably affect the result.

Previous to 1887, boiler manufacturers did not use plates more than $\frac{7}{16}''$ in thickness. About that time, a number of noted steam engineers found that $\frac{1}{2}''$ plates could be used to advantage. Later on, when higher pressures were called for, $\frac{9}{16}''$ and $\frac{5}{8}''$ plates were used, with very satisfactory results. During the last five years, 90" boilers have been constructed with $\frac{23}{32}''$ plates, and their efficiency is phenomenal. See test on page 9. With plates more than $\frac{5}{8}''$ in thickness, it is advisable to plane the edges where they lap on the girth seams down to $\frac{7}{16}''$ or $\frac{1}{2}''$. The boiler is not weakened, as the circular joints are amply strong to stand the reduction of thickness. This does not apply to the longitudinal joints, as they are above the fire surface.

The statement has often been made that horizontal tubular boilers cannot be forced beyond their rated capacity. A moment's consideration will show that the ability to force a boiler depends upon the ability to increase the draguht beyond that usually obtained. This is accomplished by the mere opening of a damper or the installation of a fan system in case the draught is insufficient. There are many cases where boilers are equipped with grates, with air spaces so fine that they soon stop up with ashes and clinkers, and in these cases an increase in draught can accomplish but little.

The boiler then gets a bad reputation, when the trouble is due solely to the grate. With an open grate and plenty of draught, there is no practical limit to the forcing, and the more the fire is driven, the more steam the boiler will generate.

In every water tube boiler there is considerable heating surface which is not effective, owing to the fact that the gases never go into the corners, and that some of the heating surface is covered with tiles. In these boilers the gases tend to and do short circuit, and go more or less in straight lines, from the edge of one set of tiles to the edge of the next, thus losing the advantage of a good deal of heating surface.

With the horizontal tubular boiler, the case is entirely different. The distance from the grate to the smoke flue is the same through every tube. There is no short circuiting of gases, either when the boiler is working gently or is being forced. When the gases pass through fire tubes, the friction causes them to roll over from centre to outside, bringing every part of them repeatedly in contact with the tube surface. Nothing can surpass this in effectiveness for causing gases to give up their heat.

As a most practical evidence of forcing, we refer to tests Nos. 4 and 5 on page 9, which were made on two of four 90″ boilers having 258-3″ tubes 20 feet long, with 4027 square feet of heating surface for each boiler. It will be observed that 42.2 pounds and 37.6 pounds of coal were burned per square foot of grate per hour, and that a boiler horse power was obtained from 6.39 and 5.43 square feet of heating surface, respectively. It will be seen that the temperature of the escaping gases was very low for such a tremendous forcing, and that the economy as shown by the evaporative rates has probably never been reached under such conditions by any other type of boiler. In tests Nos. 6 and 7, the same boilers were run near their rating, which was based on 10 square feet of heating surface per horse power, and the economic results were very extraordinary.

Test No. 2 gives results from a horizontal boiler twenty-four years old, having the original set of tubes. It shows excellent results when burning coal at a rapid rate and gives a boiler horse power from 7.7 square feet of fire heating surface.

The claim that water tube boilers are more rapid steamers and more readily respond to sudden demands than fire tube boilers, is made more often than any other. This is asserted on the assumption that they contain less weight of water in proportion to the heating surface, than do horizontal tubular boilers. This is an incorrect assumption, as can be easily shown. The four most conspicuous types of water tube boilers contain, per square foot of heating surface, 7.66 pounds, 8.34 pounds, 8.37 pounds and 8.62 pounds of water, while the 72″, 78″, 84″ and 90″ horizontal tubular boilers contain 6.73 pounds, 7.00 pounds, 7.24 and 7.65 pounds, respectively. These figures show that the claim for water tube boilers is derived from the wish rather than from the facts.

We beg to call particular attention to the weakness of the claim advanced by various water tube boiler manufacturers, viz., the element of danger in the horizontal tubular boiler. A careful examination of the records of explosions held by boiler insurance companies brings out the astonishing fact (to water tube boiler users) that, during a period of nineteen years, which is the life of the butt-strap high pressure horizontal tubular boiler, there has not been one authentic case of an explosion of this type of boiler, while during the same time, the explosions of tubes, drums and headers in water tube boiler plants have been of frequent occurence, often accompanied by loss of life, and in a number of cases, entire safety water tube boilers have exploded, causing frightful loss of

property and life. (See page 63.) These facts in regard to *safety* have caused many manufacturers to return to the horizontal tubular boilers who had previously discarded them.

In simplicity of principle, the horizontal boiler leaves nothing to be desired; and in economy, both at time of installation and after many years' usuage, it stands pre-eminent. The readiness with which the tubes can be thoroughly cleaned and the easy access to every part of the boiler, insure cleanilness at all times, which means a constant economy, even in the very old boilers.

It has also been proven that the cost of repairs on the horizontal tubular boiler is much less than on any other type of brick set boiler. Many of our boilers have been in use more than twenty years, and some few twenty-five years, with the original sets of tubes. Furthermore, there is always an open market for repairs. With other brick set boilers the tubes generally last but a few years after the boilers are installed, and in many cases can only be purchased from the builder of the boiler at an exorbitant price.

The horizontal return tubular boilers need but a chance to respond to any demand. Some makers do not seem to realize their excellence and still continue the rating of 12 square feet of heating surface per horse power, when it has been proven time and again, by tests, that a horse power can be obtained from 10 square feet, or less, depending entirely upon the size of the grate, quality of coal and the amount of coal burned per square foot of grate per hour.

The following table gives, approximately, the horse power which can be produced from a 72″ boiler containing 1500 square feet of heating surface, with different grate areas when burning 17 pounds of coal per square foot of grate per hour, also the number of square feet of heating surface per horse power with each size grate. The last column of figures gives the coal consumption per square foot of grate surface to produce the normal rating of boiler, 150 horse power.

| Size of Grate. | Ratio Heating Surface to Grate Surface. | Horse Power. | Heating Surface per Horse Power. | Coal Consumptian to produce 150 h. p. |
|---|---|---|---|---|
| 20 square feet. | 75 –1 | 100 | 15 square feet. | 25.5 pounds. |
| 25 " " | 60 –1 | 125 | 12 " " | 20.4 " |
| 30 " " | 50 –1 | 150 | 10 " " | 17 " |
| 37.5 " " | 40 –1 | 187.5 | 8 " " | 13.6 " |
| 40 " " | 37.5–1 | 200 | 7.5 " " | 12.75 " |

At a meeting of the New England Boiler Manufacturers' Association, held Oct. 31, 1907, it was decided to call 10 square feet of heating surface a horse power on all horizontal tubular boilers, and the tables on pages 23, 24, 25, 26 and 27 are based on this rating. For further information on horse power see page 50.

On page 9, twenty-one tests will be found of horizontal tubular boilers, from representative manufacturing concerns, and we wish to call attention to the results, viz., horse power developed, coal burned per square foot of grate per hour, water evaporated per pound of coal and combustible, boiler horse power developed per square foot of grate, number of square feet of heating surface per horse power, and the temperature of escaping gases. Special attention is called to the results of tests 4, 5. 6, 7, 18, 20 and 21 on 90″ boilers, of which size we make a specialty.

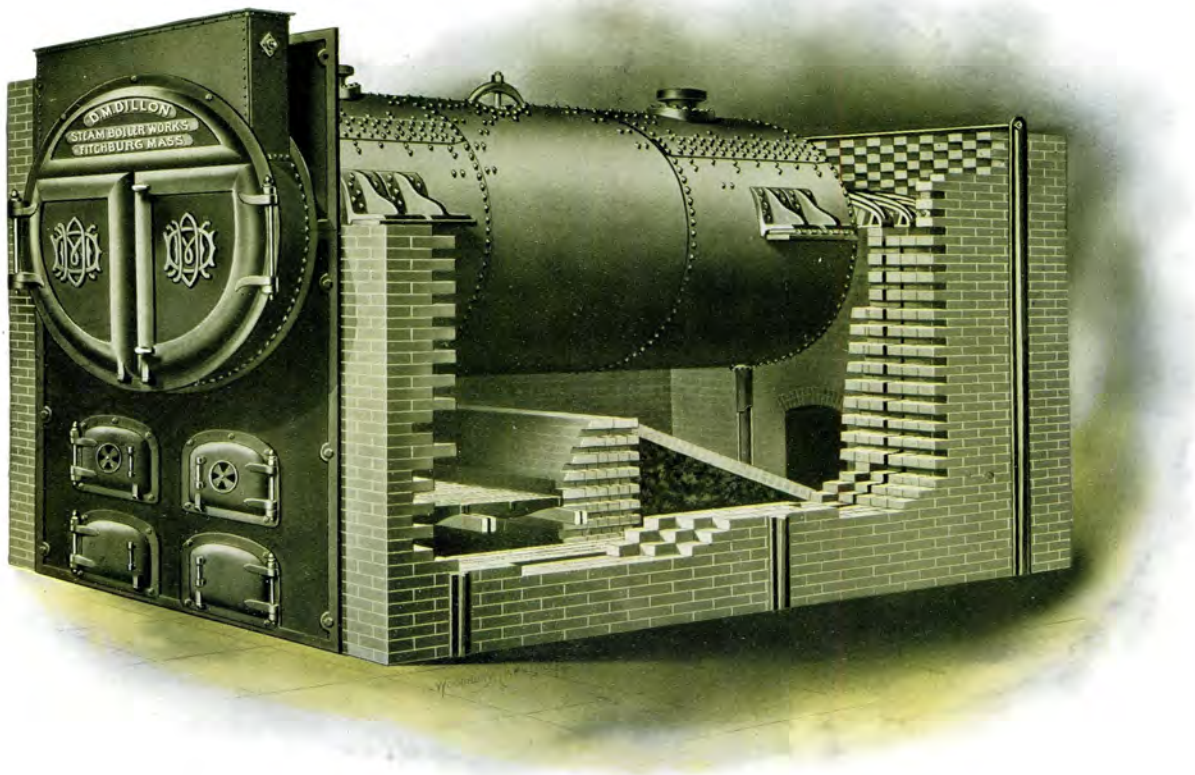
# RESULTS OF HORIZONTAL RETURN TUBULAR BOILER TESTS

| No | Year | Grate area, sq. ft. | Heating surface, sq. ft. | Steam pressure, lbs. | Boiler H. P. developed | Kind of coal | Coal burned per sq. ft. of grate per hour. Lbs. | Water evap. per hour per sq. ft. heating surface from and at 212°. Lbs. | Evaporation from and at 212° | | Boiler H. P. per sq. ft. of grate. | No. sq. ft. of heating surface per horse power | Temperature escaping gases, degrees F. | Tested by | How fired |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Per lb. coal. Lbs | Per lb. Combustible. Lbs. | | | | | |
| 1 | 1894 | 36.75 | 2164 | 67 | 167 | Pocahontas | 13.42 | 2.66 | 11.42 | 12.23 | 4.54 | 12.96 | 389 | Dean | Hand |
| *2 | 1894 | 21.51 | 1112 | 85 | 145 | Cumberland | 21.7 | 4.49 | 10.71 | 11.57 | 6.73 | 7.70 | 389 | Dean | Hand |
| 3 | 1895 | 36.00 | 1787 | 107 | 91 | Clinch Valley | 8.25 | 1.75 | 10.52 | 11.84 | 2.52 | 19.71 | 350 | Dean | Hand |
| †4 | 1900 | 48.75 | 4027 | 92 | 630 | Cumberland | 42.2 | 5.39 | 10.57 | 11.53 | 12.92 | 6.39 | 569 | Dean | Hand |
| †5 | 1900 | 61.87 | 4027 | 94 | 742 | Cumberland | 37.6 | 6.35 | 11.53 | 12.06 | 12.00 | 5.43 | 645 | Dean | Chain Grate Stk'r |
| †6 | 1900 | 48.75 | 4027 | 96 | 353 | Cumberland | 22.5 | 3.02 | 11.11 | 12.84 | 7.42 | 11.41 | 473 | Dean | Hand |
| †7 | 1900 | 61.87 | 4027 | 95 | 383 | Cumberland | 21.3 | 3.28 | 11.41 | 13.27 | 6.19 | 10.53 | 492 | Dean | Chain Grate Stk'r |
| 8 | Unknown | 90.00 | 3374 | 84 | 204 | Cumberland | 7.00 | 1.80 | 11.33 | 12.07 | 2.26 | 16.53 | 431 | Barrus | Hand |
| 9 | Unknown | 49.30 | 2100 | 65 | 178 | Cumberland | 11.10 | 2.60 | 11.20 | 11.98 | 3.61 | 11.79 | 408 | Barrus | Hand |
| ‡10 | 1902 | 49.00 | 2600 | 34 | 273 | Eureka | 17.00 | 3.60 | 11.80 | 12.70 | 5.57 | 9.52 | 448 | Hale | Hand |
| 11 | 1897 | 36.00 | 1426 | 36 | 200 | Pocahontas | 16.80 | 4.20 | 11.37 | 12.14 | 5.55 | 7.13 | 593 | Barrus | Hand |
| 12 | 1897 | 31.50 | 1426 | 58 | 168 | Pocahontas | 16.40 | 3.55 | 11.26 | 12.01 | 5.33 | 8.48 | 594 | Barrus | Hand |
| §13 | 1906 | 264.00 | 13496 | 124 | 989 | Pardee | 11.62 | 2.09 | 10.03 | 12.08 | 3.74 | 13.64 | 457 | Allen—Perkins | Hand |
| 14 | 1897 | 33.00 | 1687 | 104 | 171 | Pocahontas | 16.00 | 3.28 | 11.18 | | 5.18 | 9.86 | 392 | Allen—Shumway | Hand |
| 15 | 1906 | 33.00 | 1687 | 108 | 150 | Cumberland | 14.63 | 3.09 | 11.31 | 12.05 | 4.54 | 11.18 | 420 | Company's Eng. | Hand |
| 16 | 1904 | 33.00 | 1687 | 108 | 163 | Cumberland | 16.66 | 3.35 | 11.16 | 12.36 | 4.93 | 10.29 | 425 | Company's Eng. | Hand |
| ‖17 | 1905 | 67.5 | 2834 | 116 | 228 | Pocahontas | 10.90 | 2.78 | 10.80 | 11.90 | 3.37 | 12.42 | 443 | Green | Hand |
| †18 | 1904 | 48.75 | 3020 | 80 | 312 | Eclipse | 21.00 | 3.57 | 10.67 | 12.55 | 6.40 | 9.67 | 398 | Pead | Jones Stoker |
| 19 | 1904 | 34.00 | 1500 | 77 | 146 | Mixture of Bit. and Buckwheat | 15.90 | 3.52 | 9.87 | 12.75 | 4.29 | 10.27 | 333 | Pead | Hand |
| †20 | 1908 | 79.00 | 3820 | 107 | 479 | Pardee | 18.45 | 4.32 | 11.30 | 12.32 | 6.06 | 7.97 | 585 | Farwell | Murphy Stoker |
| †21 | 1908 | 79.00 | 3820 | 116 | 396 | Pardee | 15.00 | 3.58 | 11.77 | 12.84 | 5.01 | 9.64 | 540 | Farwell | Murphy Stoker |
| Average Evaporation, | | | | | | | | | 11.06 | 12.25 | | | | | |

* This boiler was 24 years old when tested and had the original set of tubes.
† These tests made on boilers 90″ diam.
‡ This test made on boiler 84″ diam., with 3″ tubes, 19 feet long.
§ Battery of 8 boilers.
‖ Battery of 2 boilers



D. M. DILLON STEAM BOILER WORKS, FITCHBURG, MASS.



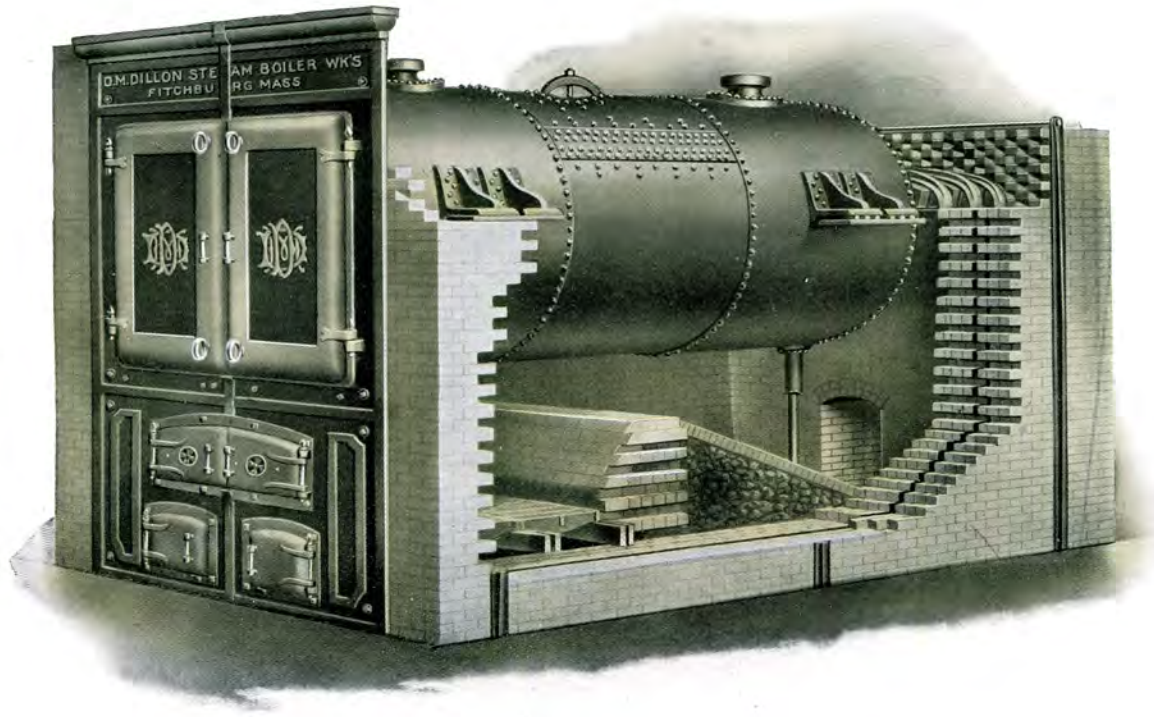

# Horizontal Return Tubular Boiler

**Showing Boiler Setting with Full Overhanging Cast-Iron Front and Two Single Furnace Doors**

WE manufacture horizontal tubular boilers in sizes from 6.6 to 452.5 horse power, based on 10 square feet of heating surface per horse power. See tables on pages 23, 24, 25, 26 and 27.

In the construction of our boilers the solid crowfoot, or the longitudinal type of bracing is used. These braces are so arranged that the tension to which each is subjected is the same. The butt-strap joints, as shown on pages 48 and 49, are used exclusively by us in all boilers and are arranged to come well above the fire line. The nozzles, brackets, blow-off flanges, safety-valve Y's, etc., are shown in detail on the following pages. Domes are furnished when desired, and the method of construction is shown on page 17.

In the small boilers, a handhole is placed in each head below the tubes, but in the larger sizes a manhole may be placed in the front head, as shown on page 13. This manhole permits of access to boiler under tubes for inspection, cleaning and repairs.



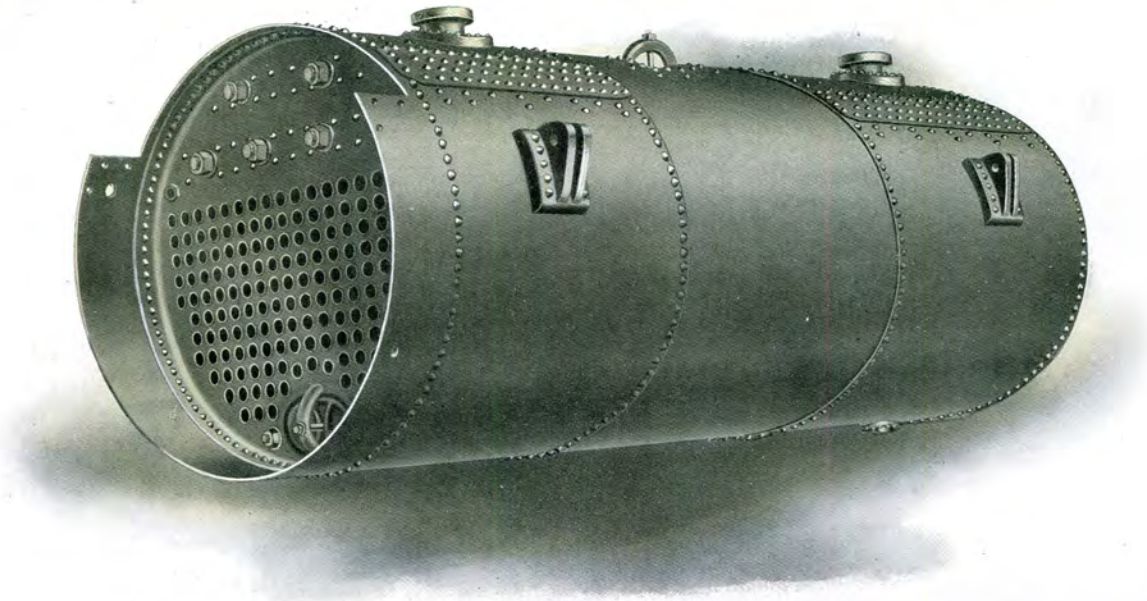

# Horizontal Return Tubular Boiler

**Showing Boiler Setting with Full Flush Cast-iron Front and Double Furnace Doors**

IN the construction of our boilers the rivet holes are first punched small, the plates then planed and rolled into a true circle, by gradual and regular increments. The courses are then bolted together and the rivet holes drilled in place $\frac{1}{16}''$ larger than the diameter of the rivet. After drilling, the plates are separated and the burrs, oil, etc., completely removed. The courses are then reassembled and the rivets driven under hydraulic pressure.

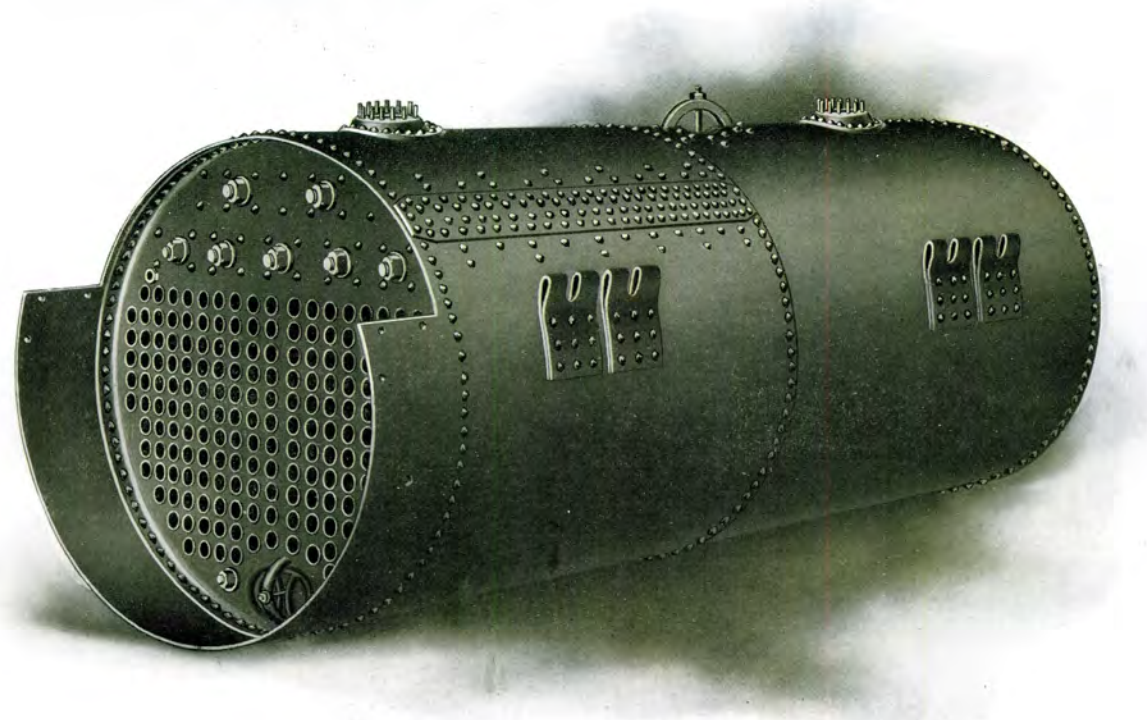
When a boiler is ordered complete, we furnish the front in any style desired, including dead plate, sides and arches for fire doors, anchor rods, rear arch bars, buckstays and rods, wall plates and rolls, cleanout door, a set of grates and bearer bars, water column, water gauge, gauge cocks, steam gauge, safety valve, and when boilers are suspended from I-beams or channels, we furnish all necessary structural work, as shown on subsequent pages.

All our boilers are tested before shipment, by some reliable boiler insurance company, to one and one-half times the maximum working pressure.



**Horizontal Return Tubular Boiler, 275 Horse Power, in Three Courses**

Showing Longitudinal Bracing, Quadruple Butt Joints, Gun Iron Hangers for Suspension, Gun Iron Nozzles and Manhole under the tubes



**Horizontal Return Tubular Boiler, 325 Horse Power, in Two Courses**

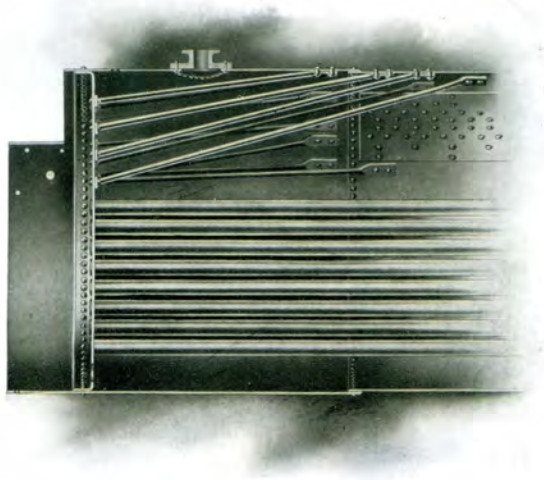
Showing Longitudinal Bracing, Quadruple Butt Joint, Steel Plate Brackets, Pressed Steel Nozzles and Manhole under the tubes. No Cast-Iron used in the construction of this boiler.

**Front End of Horizontal Tubular Boiler**

Showing Crowfoot Bracing and Handhole under the tubes.

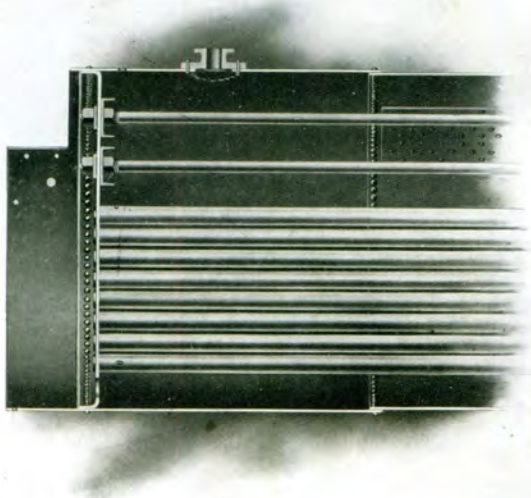
**Front End of Horizontal Tubular Boiler**

Showing Longitudinal Bracing and Manhole under the tubes.



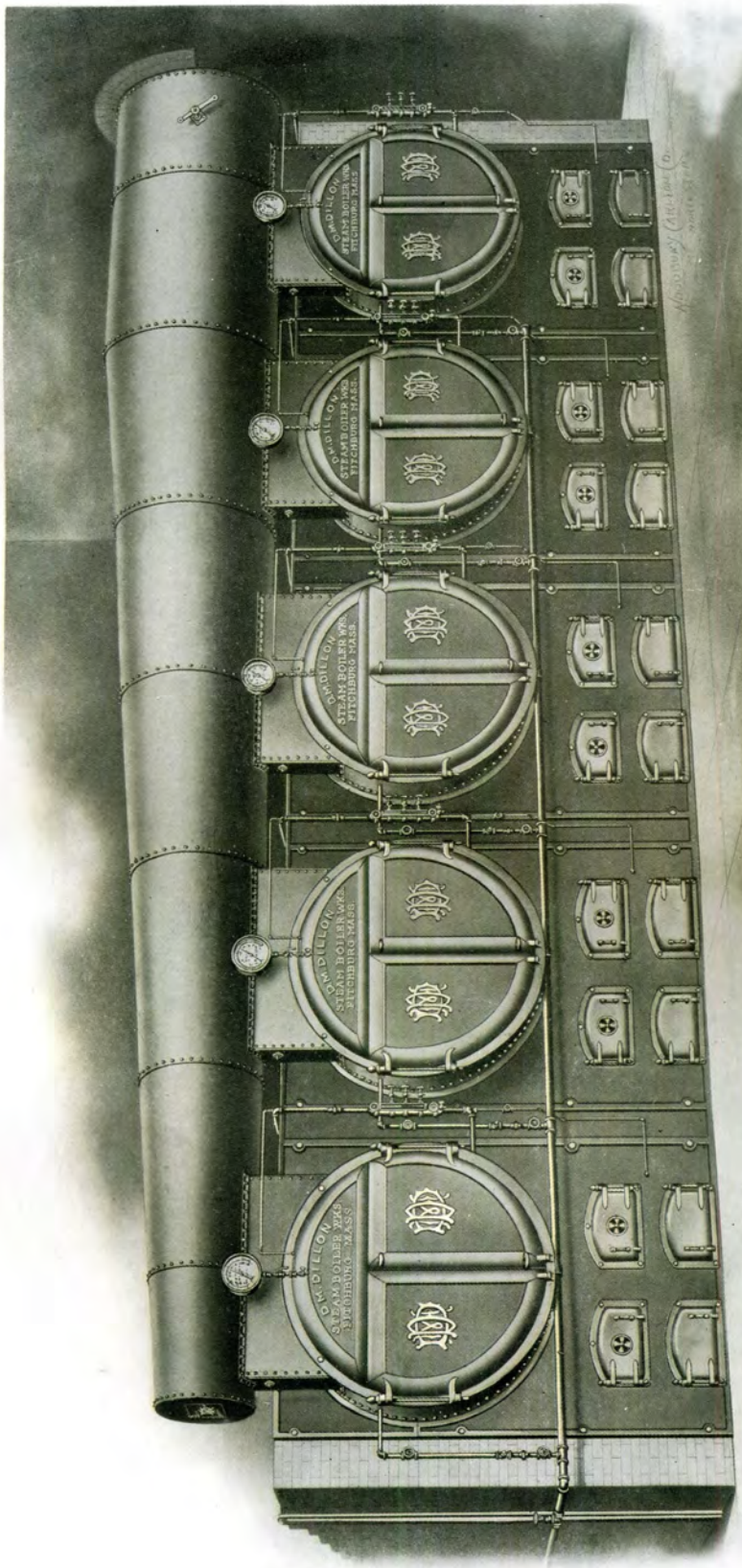
**Section of Horizontal Tubular Boiler**

Showing Crowfoot Bracing and Inside Strap of Butt-Joint.

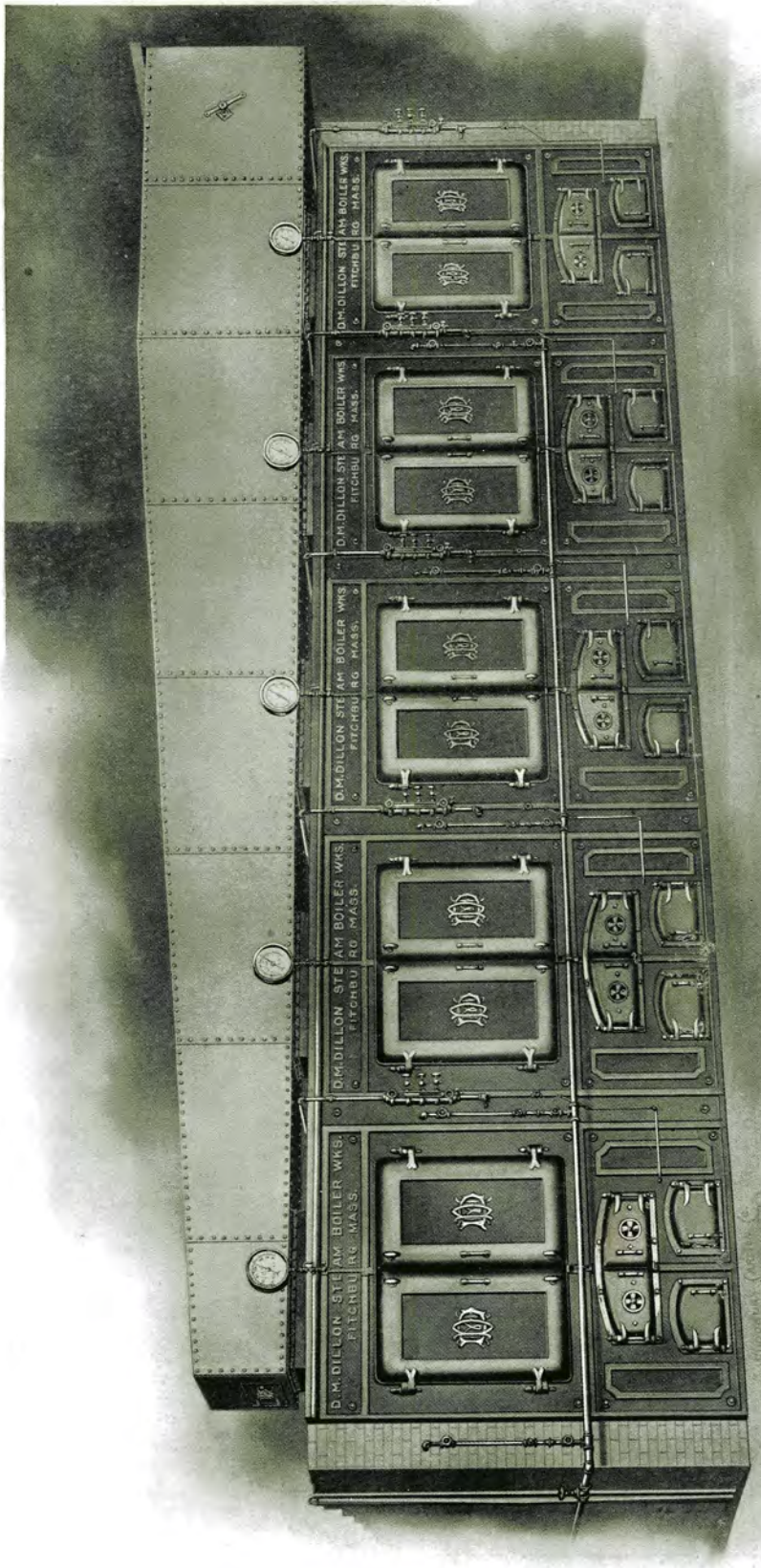


**Section of Horizontal Tubular Boiler**

Showing Longitudinal Bracing and Channel Stiffeners on inside of head.



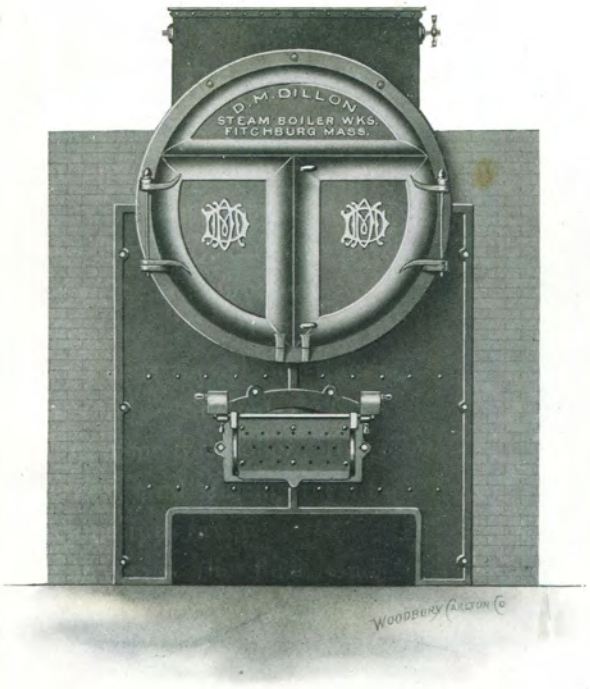

**Battery of 1000 Horse Power Horizontal Return Tubular Boilers**
Showing Overhanging Fronts and Round Smoke Flue Connection.




**Battery 1000 of Horse Power Horizontal Return Tubular Boilers**
**Showing Full Flush Fronts and Rectangular Smoke Flue Connection**

**Steel Plate Flush Front**

**Steel Plate Overhanging Front**



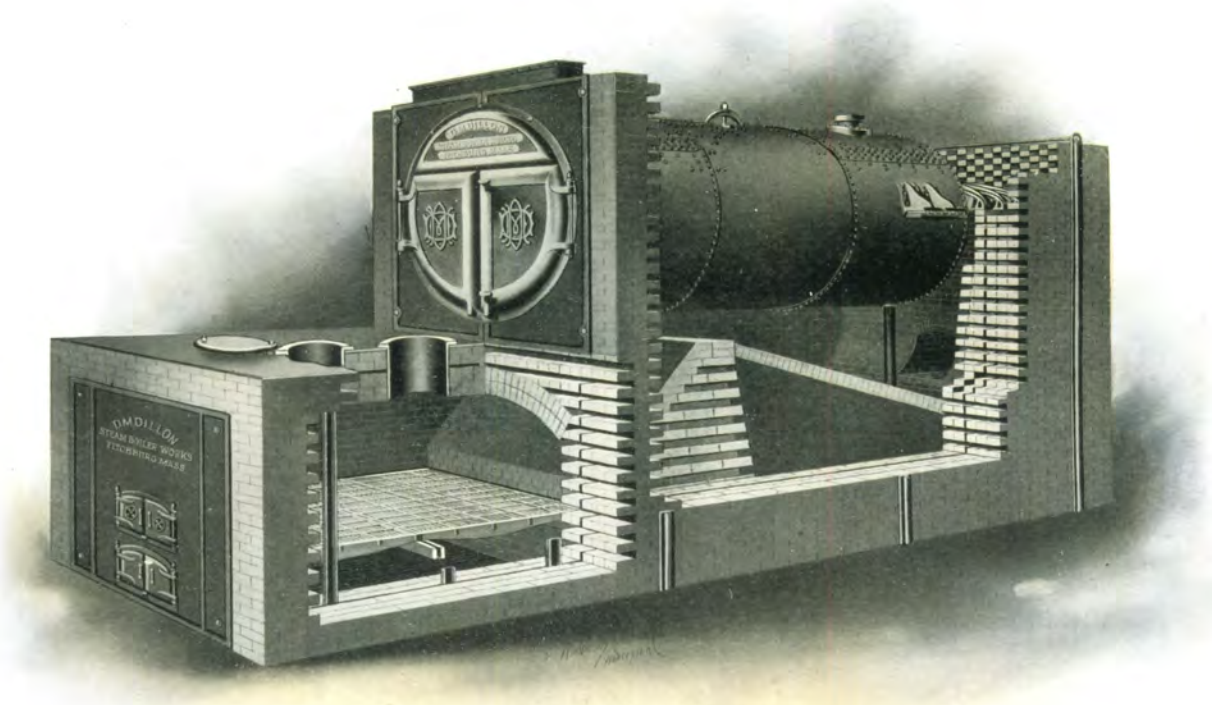

**Steel Plate Overhanging Front**
**Showing Ashcroft door and open ash-pit**

# Steel Plate Fronts

Owing to the increasing demand for steel plate fronts we have designed the improved types as shown by the cuts on this page to meet the requirements of the trade.

These fronts are constructed of thick boiler steel and securely stiffened on the furnace side. This type of boiler front cannot possibly crack, and during recent years has rapidly come into favor.

The two upper cuts of the flush and overhanging steel fronts show two single fire doors. If preferred we will furnish double fire doors as shown on page 11.



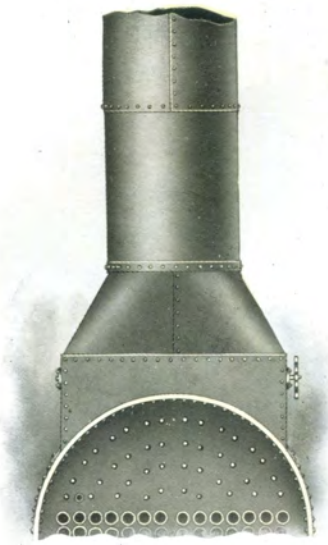

# Setting of Horizontal Return Tubular Boiler

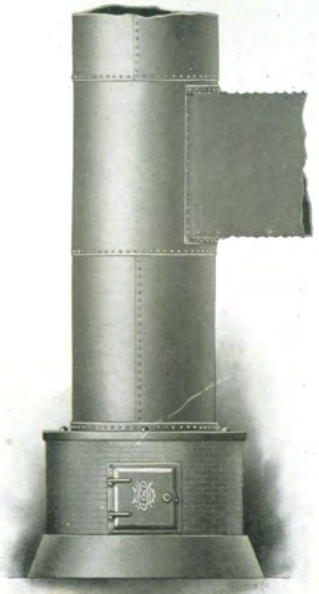
**Showing Extension Front or Dutch Oven**

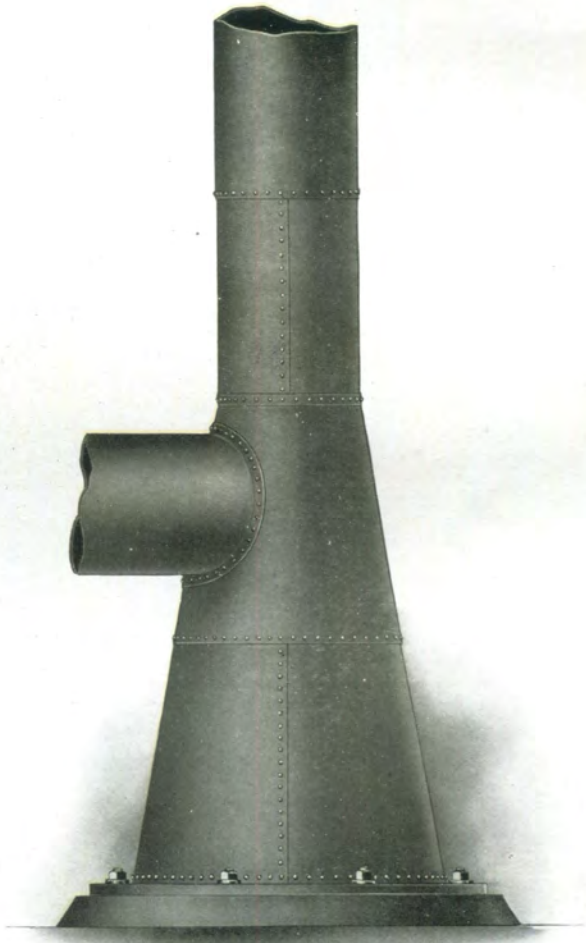
This form of setting is used in sawmills and other plants where sawdust, shavings and slabs constitute the bulk of fuel. Sawdust and shavings are fed through the openings on top of furnace, while the regular fire doors are used for coal and large slabs. On account of the large grate which is installed with this form of setting, the full rating of the boiler is obtained when green fuel is used.

# Steam Domes

Section of steam dome showing side and top steam outlets, and method of connecting to boiler. This form of dome can be applied to any size boiler. See tables on pages 29 and 31 for sizes and location.







# Steel Stacks

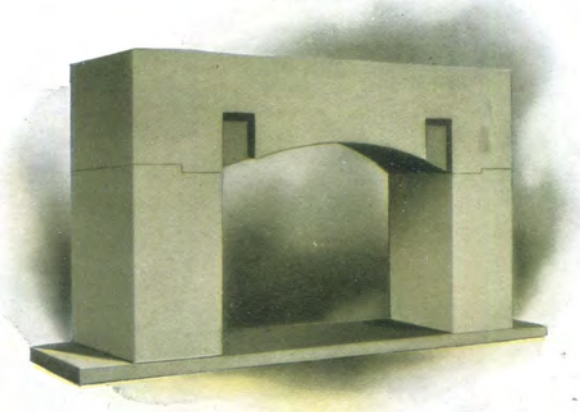
The above cuts show three different types of steel stacks, *viz.:* stack resting on dry-sheet of horizontal tubular boiler, guyed stack set on brickwork, and self-supported stack with enlarged base. We are prepared to furnish the above stacks in any desired size.

## Types of Brackets and Hangers used with Horizontal Tubular Boilers.

Strap Hanger
Gun Iron Bracket

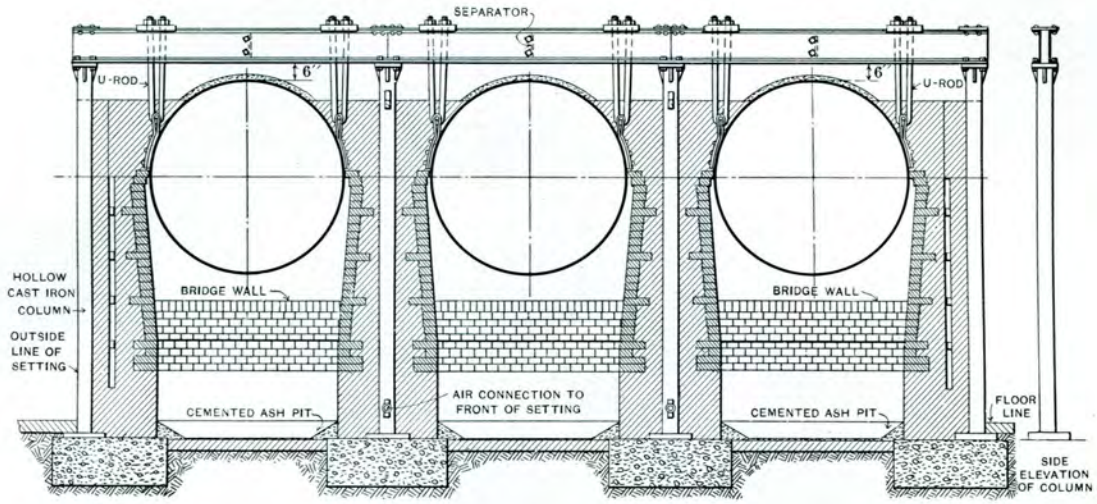
"Ryerson" Hanger
Bent Plate Hanger

Pressed Steel Bracket
Gun Iron Hanger

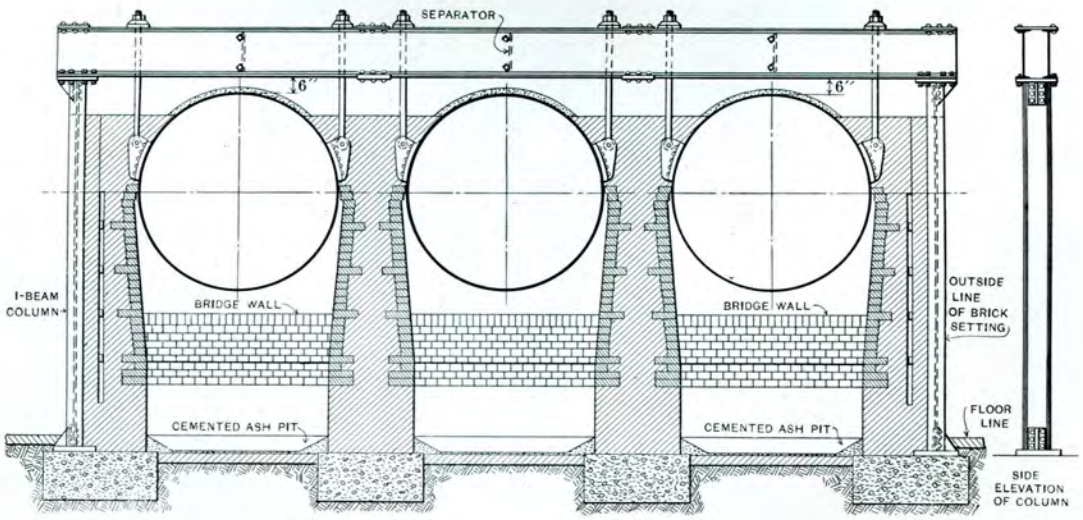


## Moulded Fire-Brick Mouthpiece

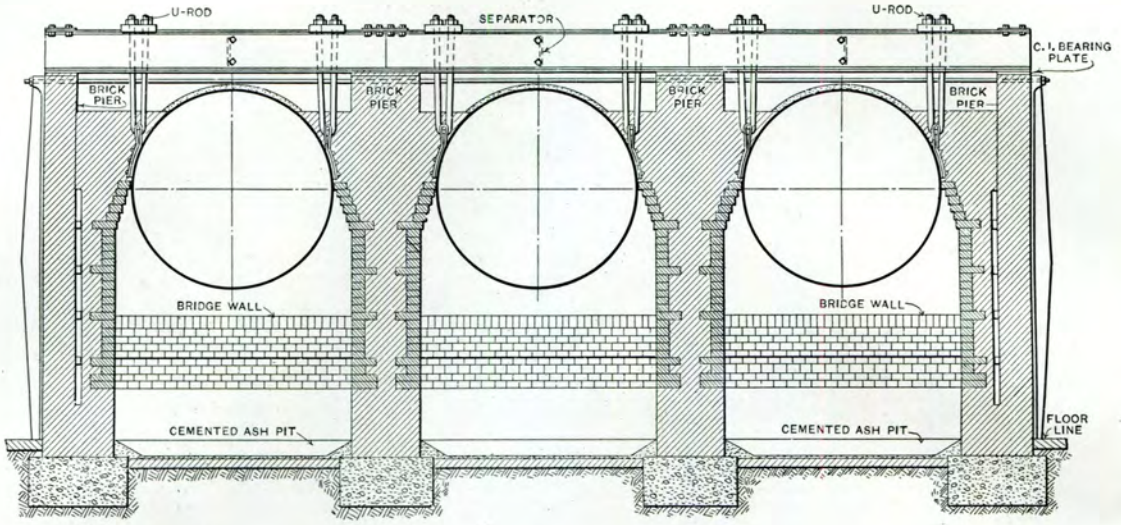
Used in connection with our Flush or Overhanging Fronts.



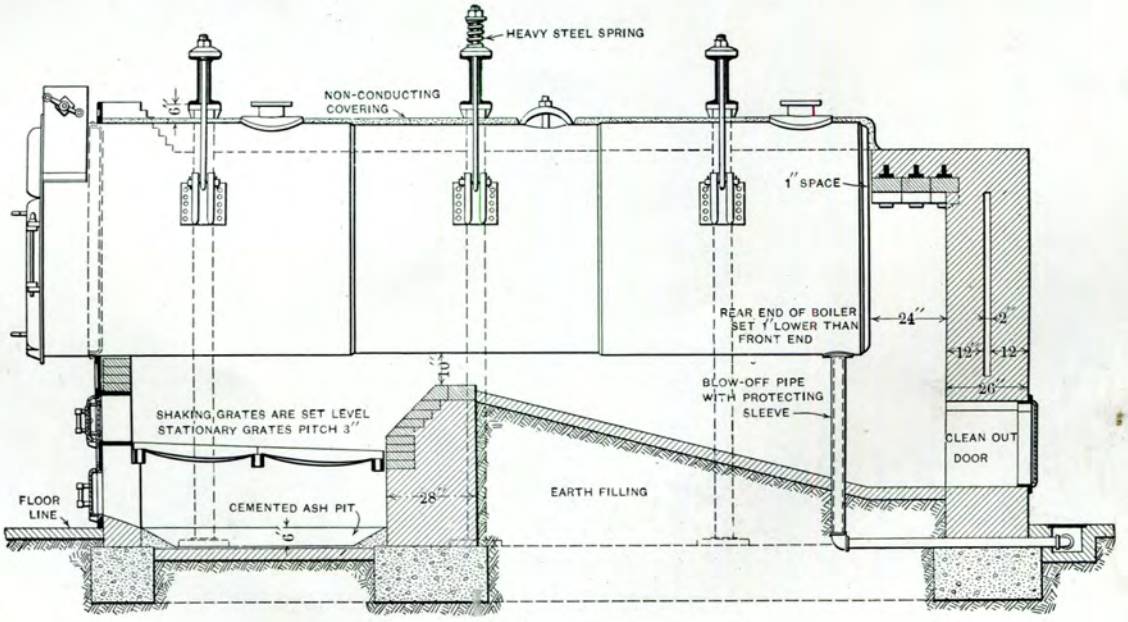

**Transverse section showing method of suspending boilers in battery, using channel girders, hollow cast-iron columns, strap hangers and U-rods.**



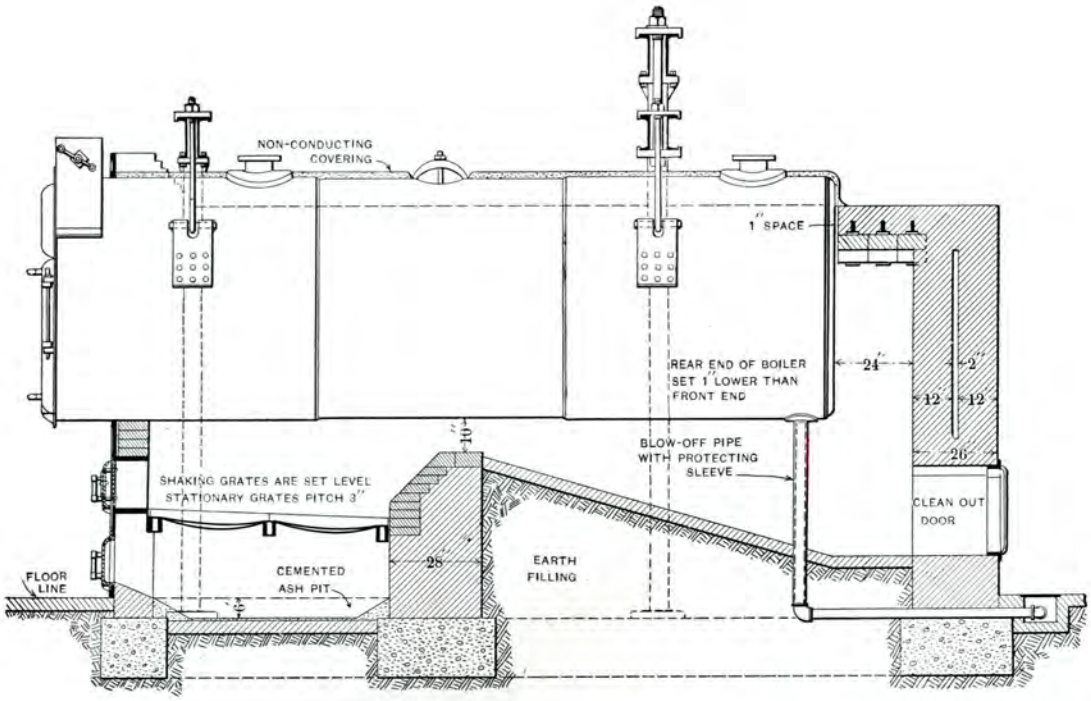

**Transverse section showing method of suspending boilers in battery, using I-beam girders and columns, gun-iron hangers and upset steel rods. No columns between boilers.**




**Transverse section showing method of suspending boilers in battery, using channel or I-beam girders resting on brickwork, strap hangers and U-rods. This section also shows method of constructing furnace for extra wide grates.**



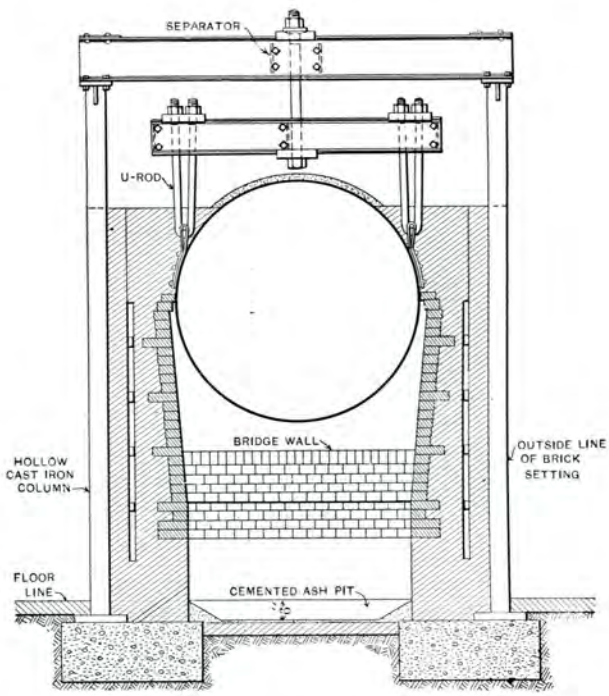

**Longitudinal section showing boiler suspended from six points, using channel girders, cast-iron columns, gun-iron hangers and upset steel rods. Heavy steel equalizing springs used on center supports.**




**Longitudinal section showing boiler suspended from three points, using channel girders, cast-iron columns, strap hangers and U-rods. Heavy upset steel rod used for third support.**

## Boiler Suspension

The foregoing drawings show several standard methods of suspending boilers in use at the present time. If one or two boilers are to be suspended we recommend that all columns be placed on the outside of setting so that they may not be unduly heated. If three or more boilers are to be used we recommend increasing the distance between boiler centers from standard measurements and placing between boilers cast-iron columns connected by air ducts to outside of setting. For general dimensions of suspension work see table on page 33.




**Transverse section**

# SIZE AND RATING OF HORIZONTAL RETURN TUBULAR BOILERS

*BASED ON TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER.

BOILERS WITH HANDHOLE IN FRONT HEAD

| Horse Power | Dia. of boiler | Length over all. | Number of tubes | Size of tubes | | §Thickness of shell for | | | | †Grate surface |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Diameter | Length | 125 lbs. pressure | 150 lbs. pressure | 175 lbs. pressure | 200 lbs. pressure | |
| | Inches | Ft. In. | | Inches | Feet | | | | | Sq. Ft. |
| 6.6 | 24 | 6-10 | 15 | 2 | 6 | 1/4 | 1/4 | 9/32 | 5/16 | 1.32 |
| 6.6 | 24 | 6-10 | 12 | 2½ | 6 | 1/4 | 1/4 | 9/32 | 5/16 | 1.32 |
| 7 6 | 24 | 7-10 | 15 | 2 | 7 | 1/4 | 1/4 | 9/32 | 5/16 | 1.52 |
| 7.7 | 24 | 7-10 | 12 | 2½ | 7 | 1/4 | 1/4 | 9/32 | 5/16 | 1.54 |
| ‡ 8.7 | 24 | 8-10 | 15 | 2 | 8 | 1/4 | 1/4 | 9/32 | 5/16 | 1.74 |
| 8.7 | 24 | 8-10 | 12 | 2½ | 8 | 1/4 | 1/4 | 9/32 | 5/16 | 1.74 |
| 9.7 | 24 | 9-10 | 15 | 2 | 9 | 1/4 | 1/4 | 9/32 | 5/16 | 1.94 |
| 9.7 | 24 | 9-10 | 12 | 2½ | 9 | 1/4 | 1/4 | 9/32 | 5/16 | 1.94 |
| 10.7 | 24 | 10-10 | 15 | 2 | 10 | 1/4 | 1/4 | 9/32 | 5/16 | 2.14 |
| 10.8 | 24 | 10-10 | 12 | 2½ | 10 | 1/4 | 1/4 | 9/32 | 5/16 | 2.16 |
| 11.7 | 24 | 11-10 | 15 | 2 | 11 | 1/4 | 1/4 | 9/32 | 5/16 | 2.34 |
| 11.8 | 24 | 11-10 | 12 | 2½ | 11 | 1/4 | 1/4 | 9/32 | 5/16 | 2.36 |
| 12.5 | 30 | 9-0 | 15 | 3 | 8 | 1/4 | 5/16 | 11/32 | 3/8 | 2.50 |
| 12.8 | 24 | 12-10 | 15 | 2 | 12 | 1/4 | 1/4 | 9/32 | 5/16 | 2.56 |
| 12.8 | 24 | 12-10 | 12 | 2½ | 12 | 1/4 | 1/4 | 9/32 | 5/16 | 2.56 |
| 13.3 | 30 | 9-0 | 20 | 2½ | 8 | 1/4 | 5/16 | 11/32 | 3/8 | 2.66 |
| 14.0 | 30 | 10-0 | 15 | 3 | 9 | 1/4 | 5/16 | 11/32 | 3/8 | 2.80 |
| 14.9 | 30 | 10-0 | 20 | 2½ | 9 | 1/4 | 5/16 | 11/32 | 3/8 | 2.98 |
| 15.5 | 30 | 11-0 | 15 | 3 | 10 | 1/4 | 5/16 | 11/32 | 3/8 | 3.10 |
| ‡ 16.5 | 30 | 11-0 | 20 | 2½ | 10 | 1/4 | 5/16 | 11/32 | 3/8 | 3.30 |
| 17.0 | 30 | 12-0 | 15 | 3 | 11 | 1/4 | 5/16 | 11/32 | 3/8 | 3.40 |
| 18.1 | 30 | 12-0 | 20 | 2½ | 11 | 1/4 | 5/16 | 11/32 | 3/8 | 3.62 |
| 18.5 | 30 | 13-0 | 15 | 3 | 12 | 1/4 | 5/16 | 11/32 | 3/8 | 3.70 |
| 19.7 | 30 | 13-0 | 20 | 2½ | 12 | 1/4 | 5/16 | 11/32 | 3/8 | 3.94 |
| 19.8 | 36 | 9-0 | 26 | 3 | 8 | 5/16 | 11/32 | 13/32 | 15/32 | 3.96 |
| 19.9 | 30 | 14-0 | 15 | 3 | 13 | 1/4 | 5/16 | 11/32 | 3/8 | 3.98 |
| 19.9 | 36 | 9-0 | 32 | 2½ | 8 | 5/16 | 11/32 | 13/32 | 15/32 | 3.98 |
| 21.3 | 30 | 14-0 | 20 | 2½ | 13 | 1/4 | 5/16 | 11/32 | 3/8 | 4.26 |
| 21.4 | 30 | 15-0 | 15 | 3 | 14 | 1/4 | 5/16 | 11/32 | 3/8 | 4.28 |
| 22.1 | 36 | 10-0 | 26 | 3 | 9 | 5/16 | 11/32 | 13/32 | 15/32 | 4.42 |
| 22.3 | 36 | 10-0 | 32 | 2½ | 9 | 5/16 | 11/32 | 13/32 | 15/32 | 4.46 |
| 22.9 | 30 | 15-0 | 20 | 2½ | 14 | 1/4 | 5/16 | 11/32 | 3/8 | 4.58 |
| 24.5 | 36 | 11-0 | 26 | 3 | 10 | 5/16 | 11/32 | 13/32 | 15/32 | 4.90 |
| ‡ 24.7 | 36 | 11-0 | 32 | 2½ | 10 | 5/16 | 11/32 | 13/32 | 15/32 | 4.94 |
| 25.3 | 42 | 9-0 | 34 | 3 | 8 | 9/32 | 11/32 | 13/32 | 15/32 | 5.06 |
| 26.9 | 36 | 12-0 | 26 | 3 | 11 | 5/16 | 11/32 | 13/32 | 15/32 | 5.38 |
| 27.1 | 36 | 12-0 | 32 | 2½ | 11 | 5/16 | 11/32 | 13/32 | 15/32 | 5.42 |
| 28.4 | 42 | 10-0 | 34 | 3 | 9 | 9/32 | 11/32 | 13/32 | 15/32 | 5.68 |
| 28.5 | 42 | 9-0 | 48 | 2½ | 8 | 9/32 | 11/32 | 13/32 | 15/32 | 5.70 |
| ‡ 29.2 | 36 | 13-0 | 26 | 3 | 12 | 5/16 | 11/32 | 13/32 | 15/32 | 5.84 |
| 29.5 | 36 | 13-0 | 32 | 2½ | 12 | 5/16 | 11/32 | 13/32 | 15/32 | 5.90 |
| 31.4 | 42 | 11-0 | 34 | 3 | 10 | 9/32 | 11/32 | 13/32 | 15/32 | 6.28 |
| 31.6 | 36 | 14-0 | 26 | 3 | 13 | 5/16 | 11/32 | 13/32 | 15/32 | 6.32 |
| 31.8 | 36 | 14-0 | 32 | 2½ | 13 | 5/16 | 11/32 | 13/32 | 15/32 | 6.36 |
| 31.9 | 42 | 10-0 | 48 | 2½ | 9 | 9/32 | 11/32 | 13/32 | 15/32 | 6.38 |
| 34.0 | 36 | 15-0 | 26 | 3 | 14 | 5/16 | 11/32 | 13/32 | 15/32 | 6.80 |
| 34.2 | 36 | 15-0 | 32 | 2½ | 14 | 5/16 | 11/32 | 13/32 | 15/32 | 6.84 |
| 34.4 | 42 | 12-0 | 34 | 3 | 11 | 9/32 | 11/32 | 13/32 | 15/32 | 6.88 |
| 35.3 | 42 | 11-0 | 48 | 2½ | 10 | 9/32 | 11/32 | 13/32 | 15/32 | 7.06 |
| ‡ 36.3 | 36 | 16-0 | 26 | 3 | 15 | 5/16 | 11/32 | 13/32 | 15/32 | 7.26 |
| 36.6 | 36 | 16-0 | 32 | 2½ | 15 | 5/16 | 11/32 | 13/32 | 15/32 | 7.32 |
| ‡ 37.4 | 42 | 13-0 | 34 | 3 | 12 | 9/32 | 11/32 | 13/32 | 15/32 | 7.48 |
| 38.7 | 36 | 17-0 | 26 | 3 | 16 | 5/16 | 11/32 | 13/32 | 15/32 | 7.74 |
| 38.7 | 42 | 12-0 | 48 | 2½ | 11 | 9/32 | 11/32 | 13/32 | 15/32 | 7.74 |

* Rating adopted by the N. E. Boiler Mfrs'. Association Oct. 31, 1907.
‡ Ratio of grate surface to heating surface equals one to fifty.

† Standard sizes usually carried in stock.
§ Tensile strength of plates, 58,000 pounds

# SIZE AND RATING OF HORIZONTAL RETURN TUBULAR BOILERS

***BASED ON TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER**

| BOILERS WITH HANDHOLE IN FRONT HEAD | | | | | | | | | | | MANHOLE IN FRONT HEAD | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Power | Dia. of boiler | Length over all. | Number of tubes | Size of tubes | | §Thickness of shell for | | | | † Grate surface | Horse Power | No. of tubes | † Grate surface |
| | | | | Diameter | Length | 125 lbs. press're | 150 lbs. press're | 175 lbs. press're | 200 lbs. press're | | | | |
| | Inches | Ft. In. | | Inches | Feet | | | | | Sq. Ft. | | | Sq Ft. |
| 39.0 | 36 | 17-0 | 32 | 2½ | 16 | 5/16 | 11/32 | 13/32 | 15/32 | 7.80 | | | |
| 40.5 | 42 | 14-0 | 34 | 3 | 13 | 9/32 | 11/32 | 13/32 | 15/32 | 8.10 | | | |
| 42.1 | 42 | 13-0 | 48 | 2½ | 12 | 9/32 | 11/32 | 13/32 | 15/32 | 8.42 | | | |
| 43.5 | 42 | 15-0 | 34 | 3 | 14 | 9/32 | 11/32 | 13/32 | 15/32 | 8.70 | | | |
| 45.5 | 42 | 14-0 | 48 | 2½ | 13 | 9/32 | 11/32 | 13/32 | 15/32 | 9.10 | | | |
| ‡ 46.5 | 42 | 16-0 | 34 | 3 | 15 | 9/32 | 11/32 | 13/32 | 15/32 | 9.30 | | | |
| 47.8 | 48 | 13-2 | 38 | 3½ | 12 | 5/16 | 3/8 | 7/16 | 1/2 | 9.56 | | | |
| 48.9 | 42 | 15-0 | 48 | 2½ | 11 | 9/32 | 11/32 | 13/32 | 15/32 | 9.78 | | | |
| 49.5 | 42 | 17-0 | 34 | 3 | 16 | 9/32 | 11/32 | 13/32 | 15/32 | 9.90 | | | |
| 51.7 | 48 | 14-2 | 38 | 3½ | 13 | 5/16 | 3/8 | 7/16 | 1/2 | 10.34 | | | |
| 52.4 | 42 | 16-0 | 48 | 2½ | 15 | 9/32 | 11/32 | 13/32 | 15/32 | 10.48 | | | |
| 52.6 | 48 | 13-2 | 50 | 3 | 12 | 5/16 | 3/8 | 7/16 | 1/2 | 10.52 | | | |
| 55.6 | 48 | 15-2 | 38 | 3½ | 14 | 5/16 | 3/8 | 7/16 | 1/2 | 11.12 | | | |
| 55.8 | 42 | 17-0 | 48 | 2½ | 16 | 9/32 | 11/32 | 13/32 | 15/32 | 11.16 | | | |
| 56.9 | 48 | 14-2 | 50 | 3 | 13 | 5/16 | 3/8 | 7/16 | 1/2 | 11.38 | | | |
| 59.4 | 48 | 16-2 | 38 | 3½ | 15 | 5/16 | 3/8 | 7/16 | 1/2 | 11.88 | | | |
| 61.2 | 48 | 15-2 | 50 | 3 | 14 | 5/16 | 3/8 | 7/16 | 1/2 | 12.24 | | | |
| 63.3 | 48 | 17-2 | 38 | 3½ | 16 | 5/16 | 3/8 | 7/16 | 1/2 | 12.66 | | | |
| ‡ 65.4 | 48 | 16-2 | 50 | 3 | 15 | 5/16 | 3/8 | 7/16 | 1/2 | 13.08 | | | |
| 67.2 | 48 | 18-2 | 38 | 3½ | 17 | 5/16 | 3/8 | 7/16 | 1/2 | 13.44 | | | |
| 69.7 | 48 | 17-2 | 50 | 3 | 16 | 5/16 | 3/8 | 7/16 | 1/2 | 13.94 | | | |
| 71.1 | 48 | 19-2 | 38 | 3½ | 18 | 5/16 | 3/8 | 7/16 | 1/2 | 14.22 | | | |
| 73.7 | 54 | 15-2 | 52 | 3½ | 14 | 3/8 | 7/16 | 1/2 | 9/16 | 14.74 | | | |
| 74.0 | 48 | 18-2 | 50 | 3 | 17 | 5/16 | 3/8 | 7/16 | 1/2 | 14.80 | | | |
| 74.9 | 54 | 15-2 | 62 | 3 | 14 | 3/8 | 7/16 | 1/2 | 9/16 | 14.98 | | | |
| 78.2 | 48 | 19-2 | 50 | 3 | 18 | 5/16 | 3/8 | 7/16 | 1/2 | 15.64 | | | |
| 78.9 | 54 | 16-2 | 52 | 3½ | 15 | 3/8 | 7/16 | 1/2 | 9/16 | 15.78 | | | |
| ‡ 80.1 | 54 | 16-2 | 62 | 3 | 15 | 3/8 | 7/16 | 1/2 | 9/16 | 16.02 | | | |
| 84.0 | 54 | 17-2 | 52 | 3½ | 16 | 3/8 | 7/16 | 1/2 | 9/16 | 16.80 | | | |
| 85.3 | 54 | 17-2 | 62 | 3 | 16 | 3/8 | 7/16 | 1/2 | 9/16 | 17.06 | | | |
| 89.2 | 54 | 18-2 | 52 | 3½ | 17 | 3/8 | 7/16 | 1/2 | 9/16 | 17.84 | | | |
| 89.6 | 60 | 15-2 | 64 | 3½ | 14 | 3/8 | 7/16 | 1/2 | 9/16 | 17.92 | 77.8 | 54 | 15.56 |
| 90.5 | 54 | 18-2 | 62 | 3 | 17 | 3/8 | 7/16 | 1/2 | 9/16 | 18.10 | | | |
| 94.3 | 54 | 19-2 | 52 | 3½ | 18 | 3/8 | 7/16 | 1/2 | 9/16 | 18.86 | | | |
| 95.8 | 54 | 19-2 | 62 | 3 | 18 | 3/8 | 7/16 | 1/2 | 9/16 | 19.16 | | | |
| 95.8 | 60 | 16-2 | 64 | 3½ | 15 | 3/8 | 7/16 | 1/2 | 9/16 | 19.16 | 83.2 | 54 | 16.64 |
| 96.7 | 60 | 15-2 | 82 | 3 | 14 | 3/8 | 7/16 | 1/2 | 9/16 | 19.34 | 86.6 | 72 | 17.32 |
| 99.4 | 54 | 20-2 | 52 | 3½ | 19 | 3/8 | 7/16 | 1/2 | 9/16 | 19.88 | | | |
| 101.0 | 54 | 20-2 | 62 | 3 | 19 | 3/8 | 7/16 | 1/2 | 9/16 | 20.20 | | | |
| 102.1 | 60 | 17-2 | 64 | 3½ | 16 | 3/8 | 7/16 | 1/2 | 9/16 | 20.42 | 88.6 | 54 | 17.72 |
| 103.5 | 60 | 16-2 | 82 | 3 | 15 | 3/8 | 7/16 | 1/2 | 9/16 | 20.70 | 92.7 | 72 | 18.54 |
| 104.6 | 54 | 21-2 | 52 | 3½ | 20 | 3/8 | 7/16 | 1/2 | 9/16 | 20.92 | | | |
| 106.2 | 54 | 21-2 | 62 | 3 | 20 | 3/8 | 7/16 | 1/2 | 9/16 | 21.24 | | | |
| 108.3 | 60 | 18-2 | 64 | 3½ | 17 | 3/8 | 7/16 | 1/2 | 9/16 | 21.66 | 93.9 | 54 | 18.78 |
| † 110.3 | 60 | 17-2 | 82 | 3 | 16 | 3/8 | 7/16 | 1/2 | 9/16 | 22.06 | 98.7 | 72 | 19.74 |
| 114.6 | 60 | 19-2 | 64 | 3½ | 18 | 3/8 | 7/16 | 1/2 | 9/16 | 22.92 | 99.3 | 54 | 19.86 |
| 115.0 | 66 | 15-4 | 84 | 3½ | 14 | 13/32 | 15/32 | 17/32 | 5/8 | 23.00 | 103.1 | 74 | 20.62 |
| 117.0 | 60 | 18-2 | 82 | 3 | 17 | 3/8 | 7/16 | 1/2 | 9/16 | 23.40 | 104.7 | 72 | 20.94 |
| 120.8 | 60 | 20-2 | 64 | 3½ | 19 | 3/8 | 7/16 | 1/2 | 9/16 | 24.16 | 104.7 | 54 | 20.94 |
| 123.0 | 66 | 16-4 | 84 | 3½ | 15 | 13/32 | 15/32 | 17/32 | 5/8 | 24.60 | 110.3 | 74 | 22.06 |
| 123.8 | 60 | 19-2 | 82 | 3 | 18 | 3/8 | 7/16 | 1/2 | 9/16 | 24.76 | 110.8 | 72 | 22.16 |
| 126.8 | 66 | 15-4 | 110 | 3 | 14 | 13/32 | 15/32 | 17/32 | 5/8 | 25.36 | 114.6 | 98 | 22.92 |
| 127.1 | 60 | 21-2 | 64 | 3½ | 20 | 3/8 | 7/16 | 1/2 | 9/16 | 25.42 | 110.1 | 54 | 22.02 |
| 130.5 | 60 | 20-2 | 82 | 3 | 19 | 3/8 | 7/16 | 1/2 | 9/16 | 26.10 | 116.8 | 72 | 23.36 |

*** Rating adopted by the N. E.** Boiler Mfrs'. Association Oct. 31, 1907.
**† Ratio of grate surface to** heating surface equals one to fifty.

‡ Standard sizes usually carried in stock.
§ Tensile strength of plates, 55,000 pounds.

# SIZE AND RATING OF HORIZONTAL RETURN TUBULAR BOILERS

***BASED ON TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER**

| Boilers with Handhole in Front Head | | | | | | | | | | | Manhole in Front Head | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Power | Dia. of boiler | Length over all. | Number of tubes | Size of tubes | | §Thickness of shell for | | | | † Grate surface | Horse Power | No. of tubes | † Grate surface |
| | | | | Diameter | Length | 125 lbs. press're | 150 lbs. press're | 175 lbs. press're | 200 lbs. press're | | | | |
| | Inches | Ft. In. | | Inches | Feet | | | | | Sq. Ft. | | | Sq. Ft. |
| 131.0 | 66 | 17-4 | 84 | 3½ | 16 | 13/32 | 15/32 | 17/32 | 5/8 | 26.20 | 117.5 | 74 | 23.50 |
| 135.6 | 66 | 16-4 | 110 | 3 | 15 | 13/32 | 15/32 | 17/32 | 5/8 | 27.12 | 122.6 | 98 | 24.52 |
| 137.3 | 60 | 21-2 | 82 | 3 | 20 | 3/8 | 7/16 | 1/2 | 9/16 | 27.46 | 122.8 | 72 | 24.56 |
| 139.1 | 66 | 18-4 | 84 | 3½ | 17 | 13/32 | 15/32 | 17/32 | 5/8 | 27.82 | 124.7 | 74 | 24.94 |
| 142.8 | 72 | 15-6 | 106 | 3½ | 14 | 7/16 | 1/2 | 19/32 | 11/16 | 28.56 | 130.9 | 96 | 26.18 |
| ‡ 144.5 | 66 | 17-4 | 110 | 3 | 16 | 13/32 | 15/32 | 17/32 | 5/8 | 28.90 | 130.6 | 98 | 26.12 |
| ‡ 147.1 | 66 | 19-4 | 84 | 3½ | 18 | 13/32 | 15/32 | 17/32 | 5/8 | 29.42 | 131.9 | 74 | 26.38 |
| 152.7 | 72 | 16-6 | 106 | 3½ | 15 | 7/16 | 1/2 | 19/32 | 11/16 | 30.54 | 140.1 | 96 | 28.02 |
| 153.4 | 66 | 18-4 | 110 | 3 | 17 | 13/32 | 15/32 | 17/32 | 5/8 | 30.68 | 138.6 | 98 | 27.72 |
| 154.8 | 72 | 15-6 | 136 | 3 | 14 | 7/16 | 1/2 | 19/32 | 11/16 | 30.96 | 142.7 | 124 | 28.54 |
| 155.1 | 66 | 20-4 | 84 | 3½ | 19 | 13/32 | 15/32 | 17/32 | 5/8 | 31.02 | 139.0 | 74 | 27.80 |
| ‡ 162.3 | 66 | 19-4 | 110 | 3 | 18 | 13/32 | 15/32 | 17/32 | 5/8 | 32.46 | 146.6 | 98 | 29.32 |
| 162.7 | 72 | 17-6 | 106 | 3½ | 16 | 7/16 | 1/2 | 19/32 | 11/16 | 32.54 | 149.2 | 96 | 29.84 |
| 163.2 | 66 | 21-4 | 84 | 3½ | 20 | 13/32 | 15/32 | 17/32 | 5/8 | 32.64 | 146.2 | 74 | 29.24 |
| 165.7 | 72 | 16-6 | 136 | 3 | 15 | 7/16 | 1/2 | 19/32 | 11/16 | 33.14 | 152.7 | 124 | 30.54 |
| 165.9 | 78 | 15-8 | 124 | 3½ | 14 | 15/32 | 9/16 | 21/32 | 23/32 | 33.18 | 154.0 | 114 | 30.80 |
| 171.1 | 66 | 20-4 | 110 | 3 | 19 | 13/32 | 15/32 | 17/32 | 5/8 | 34.22 | 154.6 | 98 | 30.92 |
| 171.2 | 66 | 22-4 | 84 | 3½ | 21 | 13/32 | 15/32 | 17/32 | 5/8 | 34.24 | 153.4 | 74 | 30.68 |
| 172.7 | 72 | 18-6 | 106 | 3½ | 17 | 7/16 | 1/2 | 19/32 | 11/16 | 34.54 | 158.4 | 96 | 31.68 |
| ‡ 176.5 | 72 | 17-6 | 136 | 3 | 16 | 7/16 | 1/2 | 19/32 | 11/16 | 35.30 | 162.6 | 124 | 32.52 |
| 176.8 | 78 | 15-8 | 156 | 3 | 14 | 15/32 | 9/16 | 21/32 | 23/32 | 35.36 | 164.7 | 144 | 32.94 |
| 177.5 | 78 | 16-8 | 124 | 3½ | 15 | 15/32 | 9/16 | 21/32 | 23/32 | 35.50 | 164.8 | 114 | 32.96 |
| 179.2 | 66 | 23-4 | 84 | 3½ | 22 | 13/32 | 15/32 | 17/32 | 5/8 | 35.84 | 160.6 | 74 | 32.12 |
| 180.0 | 66 | 21-4 | 110 | 3 | 20 | 13/32 | 15/32 | 17/32 | 5/8 | 36.00 | 162.7 | 98 | 32.54 |
| ‡ 182.7 | 72 | 19-6 | 106 | 3½ | 18 | 7/16 | 1/2 | 19/32 | 11/16 | 36.54 | 167.5 | 96 | 33.50 |
| 187.4 | 72 | 18-6 | 136 | 3 | 17 | 7/16 | 1/2 | 19/32 | 11/16 | 37.48 | 172.6 | 124 | 34.52 |
| 188.9 | 66 | 22-4 | 110 | 3 | 21 | 13/32 | 15/32 | 17/32 | 5/8 | 37.78 | 170.7 | 98 | 34.14 |
| 189.1 | 78 | 17-8 | 124 | 3½ | 16 | 15/32 | 9/16 | 21/32 | 23/32 | 37.82 | 175.6 | 114 | 35.12 |
| 189.2 | 78 | 16-8 | 156 | 3 | 15 | 15/32 | 9/16 | 21/32 | 23/32 | 37.84 | 176.2 | 144 | 35.24 |
| 192.7 | 72 | 20-6 | 106 | 3½ | 19 | 7/16 | 1/2 | 19/32 | 11/16 | 38.54 | 176.6 | 96 | 35.32 |
| 197.8 | 66 | 23-4 | 110 | 3 | 22 | 13/32 | 15/32 | 17/32 | 5/8 | 39.56 | 178.7 | 98 | 35.74 |
| ‡ 198.2 | 72 | 19-6 | 136 | 3 | 18 | 7/16 | 1/2 | 19/32 | 11/16 | 39.64 | 182.6 | 124 | 36.52 |
| 198.5 | 84 | 15-8 | 150 | 3½ | 14 | 1/2 | 19/32 | 11/16 | 25/32 | 39.70 | 189.1 | 142 | 37.82 |
| 200.7 | 78 | 18-8 | 124 | 3½ | 17 | 15/32 | 9/16 | 21/32 | 23/32 | 40.14 | 186.3 | 114 | 37.26 |
| ‡ 201.6 | 78 | 17-8 | 156 | 3 | 16 | 15/32 | 9/16 | 21/32 | 23/32 | 40.32 | 187.7 | 144 | 37.54 |
| ‡ 202.7 | 72 | 21-6 | 106 | 3½ | 20 | 7/16 | 1/2 | 19/32 | 11/16 | 40.54 | 185.8 | 96 | 37.16 |
| 209.1 | 72 | 20-6 | 136 | 3 | 19 | 7/16 | 1/2 | 19/32 | 11/16 | 41.82 | 192.6 | 124 | 38.52 |
| ‡ 212.3 | 78 | 19-8 | 124 | 3½ | 18 | 15/32 | 9/16 | 21/32 | 23/32 | 42.46 | 197.1 | 114 | 39.42 |
| 212.4 | 84 | 16-8 | 150 | 3½ | 15 | 1/2 | 19/32 | 11/16 | 25/32 | 42.48 | 202.3 | 142 | 40.46 |
| 212.7 | 72 | 22-6 | 106 | 3½ | 21 | 7/16 | 1/2 | 19/32 | 11/16 | 42.54 | 194.9 | 96 | 38.98 |
| 214.0 | 78 | 18-8 | 156 | 3 | 17 | 15/32 | 9/16 | 21/32 | 23/32 | 42.80 | 199.3 | 144 | 39.86 |
| 217.2 | 84 | 15-8 | 194 | 3 | 14 | 1/2 | 19/32 | 11/16 | 25/32 | 43.44 | 203.0 | 180 | 40.60 |
| ‡ 219.9 | 72 | 21-6 | 136 | 3 | 20 | 7/16 | 1/2 | 19/32 | 11/16 | 43.98 | 202.5 | 124 | 40.50 |
| 222.7 | 72 | 23-6 | 106 | 3½ | 22 | 7/16 | 1/2 | 19/32 | 11/16 | 44.54 | 204.0 | 96 | 40.80 |
| 223.9 | 78 | 20-8 | 124 | 3½ | 19 | 15/32 | 9/16 | 21/32 | 23/32 | 44.78 | 207.8 | 114 | 41.56 |
| 226.3 | 84 | 17-8 | 150 | 3½ | 16 | 1/2 | 19/32 | 11/16 | 25/32 | 45.26 | 215.5 | 142 | 43.10 |
| ‡ 226.4 | 78 | 19-8 | 156 | 3 | 18 | 15/32 | 9/16 | 21/32 | 23/32 | 45.28 | 210.8 | 144 | 42.16 |
| 230.7 | 72 | 22-6 | 136 | 3 | 21 | 7/16 | 1/2 | 19/32 | 11/16 | 46.14 | 212.5 | 124 | 42.50 |
| 231.2 | 90 | 15-10 | 176 | 3½ | 14 | 17/32 | 9/16 | 3/4 | 27/32 | 46.24 | 221.8 | 168 | 44.36 |
| 232.4 | 84 | 16-8 | 194 | 3 | 15 | 1/2 | 19/32 | 11/16 | 25/32 | 46.48 | 217.2 | 180 | 43.44 |
| ‡ 235.5 | 78 | 21-8 | 124 | 3½ | 20 | 15/32 | 9/16 | 21/32 | 23/32 | 47.10 | 218.6 | 114 | 43.72 |
| 238.8 | 78 | 20-8 | 156 | 3 | 19 | 15/32 | 9/16 | 21/32 | 23/32 | 47.76 | 222.3 | 144 | 44.46 |
| 240.2 | 84 | 18-8 | 150 | 3½ | 17 | 1/2 | 19/32 | 11/16 | 25/32 | 48.04 | 228.7 | 142 | 45.74 |
| 241.6 | 72 | 23-6 | 136 | 3 | 22 | 7/16 | 1/2 | 19/32 | 11/16 | 48.32 | 222.5 | 124 | 44.50 |

* Rating adopted by the N. E. Boiler Mfrs'. Association Oct. 31, 1907.
† Ratio of grate surface to heating surface equals one to fifty.

‡ Standard sizes usually carried in stock.
§ Tensile strength of plates, 58,000 pounds.

# SIZE AND RATING OF HORIZONTAL RETURN TUBULAR BOILERS

***BASED ON TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER**

| BOILERS WITH HANDHOLE IN FRONT HEAD | | | | | | | | | | | MANHOLE IN FRONT HEAD | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Power | Dia. of boiler | Length over all. | Number of tubes | Size of tubes | | §Thickness of shell for | | | | † Grate surface | Horse Power | No. of tubes | † Grate surface |
| | | | | Diameter | Length | 125 lbs. press're | 150 lbs. press're | 175 lbs. press're | 200 lbs. press're | | | | |
| | Inches | Ft. In. | | Inches | Feet | | | | | Sq. Ft. | | | Sq. Ft. |
| 247.1 | 78 | 22-8 | 124 | 3½ | 21 | 15/32 | 9/16 | 21/32 | 23/32 | 49.42 | 229.3 | 114 | 45.86 |
| 247.4 | 90 | 16-10 | 176 | 3½ | 15 | 17/32 | 5/8 | 3/4 | 27/32 | 49.48 | 237.3 | 168 | 47.46 |
| ‡ 247.6 | 84 | 17-8 | 194 | 3 | 16 | 1/2 | 19/32 | 11/16 | 25/32 | 49.52 | 231.4 | 180 | 46.28 |
| 249.4 | 90 | 15-10 | 224 | 3 | 14 | 17/32 | 5/8 | 3/4 | 27/32 | 49.88 | 235.3 | 210 | 47.06 |
| ‡ 251.1 | 78 | 21-8 | 156 | 3 | 20 | 15/32 | 9/16 | 21/32 | 23/32 | 50.22 | 233.8 | 144 | 46.76 |
| ‡ 254.1 | 84 | 19-8 | 150 | 3½ | 18 | 1/2 | 19/32 | 11/16 | 25/32 | 50.82 | 242.0 | 142 | 48.40 |
| 258.7 | 78 | 23-8 | 124 | 3½ | 22 | 15/32 | 9/16 | 21/32 | 23/32 | 51.74 | 240.1 | 114 | 48.02 |
| 261.6 | 96 | 15-10 | 200 | 3½ | 14 | 9/16 | 11/16 | 25/32 | 29/32 | 52.32 | 249.8 | 190 | 49.96 |
| 262.8 | 84 | 18-8 | 194 | 3 | 17 | 1/2 | 19/32 | 11/16 | 25/32 | 52.56 | 245.6 | 180 | 49.12 |
| 263.5 | 78 | 22-8 | 156 | 3 | 21 | 15/32 | 9/16 | 21/32 | 23/32 | 52.70 | 245.3 | 144 | 49.06 |
| 263.6 | 90 | 17-10 | 176 | 3½ | 16 | 17/32 | 5/8 | 3/4 | 27/32 | 52.72 | 252.8 | 168 | 50.56 |
| 266.9 | 90 | 16-10 | 224 | 3 | 15 | 17/32 | 5/8 | 3/4 | 27/32 | 53.38 | 251.8 | 210 | 50.36 |
| 268.0 | 84 | 20-8 | 150 | 3½ | 19 | 1/2 | 19/32 | 11/16 | 25/32 | 53.60 | 255.2 | 142 | 51.04 |
| 275.9 | 78 | 23-8 | 156 | 3 | 22 | 15/32 | 9/16 | 21/32 | 23/32 | 55.18 | 256.8 | 144 | 51.36 |
| ‡ 278.1 | 84 | 19-8 | 194 | 3 | 18 | 1/2 | 19/32 | 11/16 | 25/32 | 55.62 | 259.9 | 180 | 51.98 |
| 279.8 | 90 | 18-10 | 176 | 3½ | 17 | 17/32 | 5/8 | 3/4 | 27/32 | 55.96 | 268.3 | 168 | 53.66 |
| 280.0 | 96 | 16-10 | 200 | 3½ | 15 | 9/16 | 11/16 | 25/32 | 29/32 | 56.00 | 267.3 | 190 | 53.46 |
| ‡ 281.9 | 84 | 21-8 | 150 | 3½ | 20 | 1/2 | 19/32 | 11/16 | 25/32 | 56.38 | 268.4 | 142 | 53.68 |
| ‡ 284.4 | 90 | 17-10 | 224 | 3 | 16 | 17/32 | 5/8 | 3/4 | 27/32 | 56.88 | 268.2 | 210 | 53.64 |
| 289.8 | 96 | 15-10 | 262 | 3 | 14 | 9/16 | 11/16 | 25/32 | 29/32 | 57.96 | 275.7 | 248 | 55.14 |
| 293.3 | 84 | 20-8 | 194 | 3 | 19 | 1/2 | 19/32 | 11/16 | 25/32 | 58.66 | 274.1 | 180 | 54.82 |
| 295.8 | 84 | 22-8 | 150 | 3½ | 21 | 1/2 | 19/32 | 11/16 | 25/32 | 59.16 | 281.6 | 142 | 56.32 |
| ‡ 296.0 | 90 | 19-10 | 176 | 3½ | 18 | 17/32 | 5/8 | 3/4 | 27/32 | 59.20 | 283.8 | 168 | 56.76 |
| 298.3 | 96 | 17-10 | 200 | 3½ | 16 | 9/16 | 11/16 | 25/32 | 29/32 | 59.66 | 284.8 | 190 | 56.96 |
| 301.9 | 90 | 18-10 | 224 | 3 | 17 | 17/32 | 5/8 | 3/4 | 27/32 | 60.38 | 284.7 | 210 | 56.94 |
| ‡ 308.5 | 84 | 21-8 | 194 | 3 | 20 | 1/2 | 19/32 | 11/16 | 25/32 | 61.70 | 288.3 | 180 | 57.66 |
| 309.7 | 84 | 23-8 | 150 | 3½ | 22 | 1/2 | 19/32 | 11/16 | 25/32 | 61.94 | 294.8 | 142 | 58.96 |
| 310.2 | 96 | 16-10 | 262 | 3 | 15 | 9/16 | 11/16 | 25/32 | 29/32 | 62.04 | 295.0 | 248 | 59.00 |
| 312.2 | 90 | 20-10 | 176 | 3½ | 19 | 17/32 | 5/8 | 3/4 | 27/32 | 62.44 | 299.3 | 168 | 59.86 |
| 316.6 | 96 | 18-10 | 200 | 3½ | 17 | 9/16 | 11/16 | 25/32 | 29/32 | 63.32 | 302.2 | 190 | 60.44 |
| ‡ 319.4 | 90 | 19-10 | 224 | 3 | 18 | 17/32 | 5/8 | 3/4 | 27/32 | 63.88 | 301.2 | 210 | 60.24 |
| 323.8 | 84 | 22-8 | 194 | 3 | 21 | 1/2 | 19/32 | 11/16 | 25/32 | 64.76 | 302.5 | 180 | 60.50 |
| ‡ 328.4 | 90 | 21-10 | 176 | 3½ | 20 | 17/32 | 5/8 | 3/4 | 27/32 | 65.68 | 314.9 | 168 | 62.98 |
| ‡ 330.5 | 96 | 17-10 | 262 | 3 | 16 | 9/16 | 11/16 | 25/32 | 29/32 | 66.10 | 314.4 | 248 | 62.88 |
| ‡ 334 9 | 96 | 19-10 | 200 | 3½ | 18 | 9/16 | 11/16 | 25/32 | 29/32 | 66.98 | 319.7 | 190 | 63.94 |
| 336 9 | 90 | 20-10 | 224 | 3 | 19 | 17/32 | 5/8 | 3/4 | 27/32 | 67.38 | 317.7 | 210 | 63.54 |
| 339.9 | 84 | 23-8 | 194 | 3 | 22 | 1/2 | 19/32 | 11/16 | 25/32 | 67.80 | 316.7 | 180 | 63.34 |
| 344.6 | 90 | 22-10 | 176 | 3½ | 21 | 17/32 | 5/8 | 3/4 | 27/32 | 68.92 | 330.4 | 168 | 66.08 |
| 350.9 | 96 | 18-10 | 262 | 3 | 17 | 9/16 | 11/16 | 25/32 | 29/32 | 70.18 | 333.7 | 248 | 66.74 |
| 353.3 | 96 | 20-10 | 200 | 3½ | 19 | 9/16 | 11/16 | 25/32 | 29/32 | 70.66 | 337.2 | 190 | 67.44 |
| ‡ 354.4 | 90 | 21-10 | 224 | 3 | 20 | 17/32 | 5/8 | 3/4 | 27/32 | 70.88 | 334.1 | 210 | 66.82 |
| 360.8 | 90 | 23-10 | 176 | 3½ | 22 | 17/32 | 5/8 | 3/4 | 27/32 | 72.16 | 345.9 | 168 | 69.18 |
| ‡ 371.2 | 96 | 19-10 | 262 | 3 | 18 | 9/16 | 11/16 | 25/32 | 29/32 | 74.24 | 353.0 | 248 | 70.60 |
| ‡ 371.6 | 96 | 21-10 | 200 | 3½ | 20 | 9/16 | 11/16 | 25/32 | 29/32 | 74.32 | 354.6 | 190 | 70.92 |
| 371.9 | 90 | 22-10 | 224 | 3 | 21 | 17/32 | 5/8 | 3/4 | 27/32 | 74.38 | 350.6 | 210 | 70.12 |
| 389.4 | 90 | 23-10 | 224 | 3 | 22 | 17/32 | 5/8 | 3/4 | 27/32 | 77.88 | 367.1 | 210 | 73.42 |
| 389.9 | 96 | 22-10 | 200 | 3½ | 21 | 9/16 | 11/16 | 25/32 | 29/32 | 77.98 | 372.1 | 190 | 74.42 |
| 391.5 | 96 | 20-10 | 262 | 3 | 19 | 9/16 | 11/16 | 25/32 | 29/32 | 78.30 | 372.3 | 248 | 74.46 |
| 408.2 | 96 | 23-10 | 200 | 3½ | 22 | 9/16 | 11/16 | 25/32 | 29/32 | 81.64 | 389.6 | 190 | 77.92 |
| ‡ 411.9 | 96 | 21-10 | 262 | 3 | 20 | 9/16 | 11/16 | 25/32 | 29/32 | 82.38 | 391.6 | 248 | 78.32 |
| 432.2 | 96 | 22-10 | 262 | 3 | 21 | 9/16 | 11/16 | 25/32 | 29/32 | 86.44 | 410.9 | 248 | 82.18 |
| 452.5 | 96 | 23-10 | 262 | 3 | 22 | 9/16 | 11/16 | 25/32 | 29/32 | 90.50 | 430.3 | 248 | 86.06 |

* Rating adopted by the N. E. Boiler Mfrs'. Association Oct. 31, 1907.
‡ Ratio of grate surface to heating surface equals one to fifty.

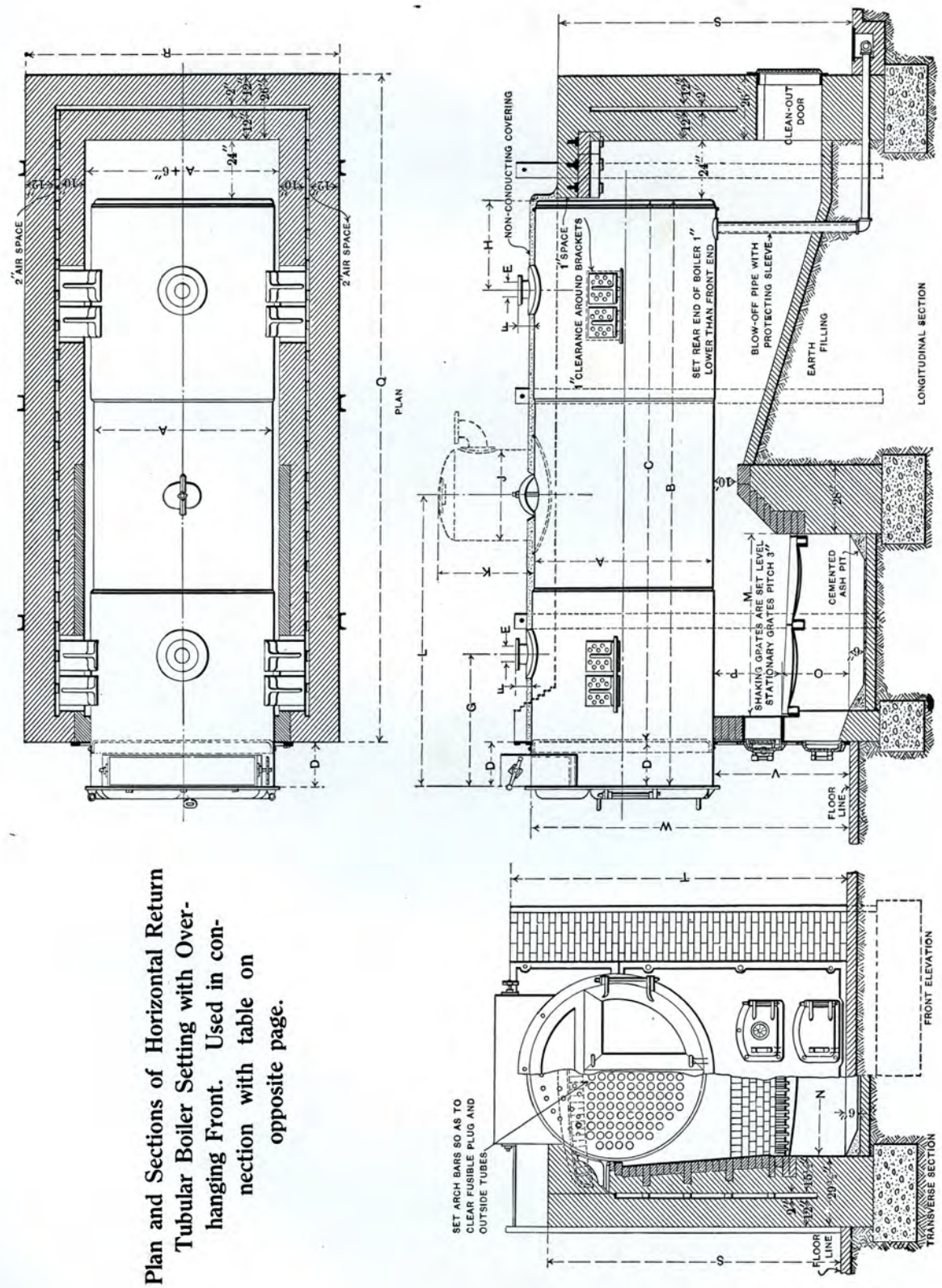
† Standard sizes usually carried in stock.
§ Tensile strength of plates, 58,000 pounds.

# *SIZE AND RATING OF HORIZONTAL RETURN TUBULAR BOILERS

† BASED ON TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER

| Boilers with Handhole in Front Head | | | | | | Manhole in F. Hd. | | Boilers with Handhole in Front Head | | | | | | Manhole in F. Hd. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dia. of boiler | Length over all | No. of tubes | Size of tubes Dia. | Size of tubes L'th. | Horse pow'r | No. of tubes | Horse power | Dia. of boiler | Length over all | No. of tubes | Size of tubes Dia. | Size of tubes L'th. | Horse power | No. of tubes | Horse power |
| In. | Ft. In. | | In. | Ft. | | | | In. | Ft. In. | | In. | Ft. | | | |
| 48 | 13-2 | 50 | 3 | 12 | 52.6 | | | 66 | 21-4 | 110 | 3 | 20 | 180.0 | 98 | 162.7 |
| 48 | 13-2 | 38 | 3½ | 12 | 47.8 | | | 66 | 21-4 | 84 | 3½ | 20 | 163.2 | 74 | 146.2 |
| 48 | 14-2 | 50 | 3 | 13 | 56.9 | | | 72 | 15-6 | 136 | 3 | 14 | 154.8 | 124 | 142.7 |
| 48 | 14-2 | 38 | 3½ | 13 | 51.7 | | | 72 | 15-6 | 106 | 3½ | 14 | 142.8 | 96 | 130.9 |
| 48 | 15-2 | 50 | 3 | 14 | 61.2 | | | 72 | 16-6 | 136 | 3 | 15 | 165.7 | 124 | 152.7 |
| 48 | 15-2 | 38 | 3½ | 14 | 55.6 | | | 72 | 16-6 | 106 | 3½ | 15 | 152.7 | 96 | 140.1 |
| 48 | 16-2 | 50 | 3 | 15 | 65.4 | | | 72 | 17-6 | 136 | 3 | 16 | 176.5 | 124 | 162.6 |
| 48 | 16-2 | 38 | 3½ | 15 | 59.4 | | | 72 | 17-6 | 106 | 3½ | 16 | 162.7 | 96 | 149.2 |
| 48 | 17-2 | 50 | 3 | 16 | 69.7 | | | 72 | 18-6 | 136 | 3 | 17 | 187.4 | 124 | 172.6 |
| 48 | 17-2 | 38 | 3½ | 16 | 63.3 | | | 72 | 18-6 | 106 | 3½ | 17 | 172.7 | 96 | 158.4 |
| 48 | 18-2 | 50 | 3 | 17 | 74.0 | | | 72 | 19-6 | 136 | 3 | 18 | 198.2 | 124 | 182.6 |
| 48 | 18-2 | 38 | 3½ | 17 | 67.2 | | | 72 | 19-6 | 106 | 3½ | 18 | 182.7 | 96 | 167.5 |
| 48 | 19-2 | 50 | 3 | 18 | 78.2 | | | 72 | 20-6 | 136 | 3 | 19 | 209.1 | 124 | 192.6 |
| 48 | 19-2 | 38 | 3½ | 18 | 71.1 | | | 72 | 20-6 | 106 | 3½ | 19 | 192.7 | 96 | 176.6 |
| 54 | 15-2 | 62 | 3 | 14 | 74.9 | | | 72 | 21-6 | 136 | 3 | 20 | 219.9 | 124 | 202.5 |
| 54 | 15-2 | 52 | 3½ | 14 | 73.7 | | | 72 | 21-6 | 106 | 3½ | 20 | 202.7 | 96 | 185.8 |
| 54 | 16-2 | 62 | 3 | 15 | 80.1 | | | 78 | 15-8 | 156 | 3 | 14 | 176.8 | 144 | 164.7 |
| 54 | 16-2 | 52 | 3½ | 15 | 78.9 | | | 78 | 15-8 | 124 | 3½ | 14 | 165.9 | 114 | 154.0 |
| 54 | 17-2 | 62 | 3 | 16 | 85.3 | | | 78 | 16-8 | 156 | 3 | 15 | 189.2 | 144 | 176.2 |
| 54 | 17-2 | 52 | 3½ | 16 | 84.0 | | | 78 | 16-8 | 124 | 3½ | 15 | 177.5 | 114 | 164.8 |
| 54 | 18-2 | 62 | 3 | 17 | 90.5 | | | 78 | 17-8 | 156 | 3 | 16 | 201.6 | 144 | 187.7 |
| 54 | 18-2 | 52 | 3½ | 17 | 89.2 | | | 78 | 17-8 | 124 | 3½ | 16 | 189.1 | 114 | 175.6 |
| 54 | 19-2 | 62 | 3 | 18 | 95.8 | | | 78 | 18-8 | 156 | 3 | 17 | 214.0 | 144 | 199.3 |
| 54 | 19-2 | 52 | 3½ | 18 | 94.3 | | | 78 | 18-8 | 124 | 3½ | 17 | 200.7 | 114 | 186.3 |
| 54 | 20-2 | 62 | 3 | 19 | 101.0 | | | 78 | 19-8 | 156 | 3 | 18 | 226.4 | 144 | 210.8 |
| 54 | 20-2 | 52 | 3½ | 19 | 99.4 | | | 78 | 19-8 | 124 | 3½ | 18 | 212.3 | 114 | 197.1 |
| 54 | 21-2 | 62 | 3 | 20 | 106.2 | | | 78 | 20-8 | 156 | 3 | 19 | 238.8 | 144 | 222.3 |
| 54 | 21-2 | 52 | 3½ | 20 | 104.6 | | | 78 | 20-8 | 124 | 3½ | 19 | 223.9 | 114 | 207.8 |
| 60 | 15-2 | 82 | 3 | 14 | 96.7 | 72 | 86.6 | 78 | 21-8 | 156 | 3 | 20 | 251.1 | 144 | 233.8 |
| 60 | 15-2 | 64 | 3½ | 14 | 89.6 | 54 | 77.8 | 78 | 21-8 | 124 | 3½ | 20 | 235.5 | 114 | 218.6 |
| 60 | 16-2 | 82 | 3 | 15 | 103.5 | 72 | 92.7 | 84 | 16-8 | 194 | 3 | 15 | 232.4 | 180 | 217.2 |
| 60 | 16-2 | 64 | 3½ | 15 | 95.8 | 54 | 83.2 | 84 | 16-8 | 150 | 3½ | 15 | 212.4 | 142 | 202.3 |
| 60 | 17-2 | 82 | 3 | 16 | 110.3 | 72 | 98.7 | 84 | 17-8 | 194 | 3 | 16 | 247.6 | 180 | 231.4 |
| 60 | 17-2 | 64 | 3½ | 16 | 102.1 | 54 | 88.6 | 84 | 17-8 | 150 | 3½ | 16 | 226.3 | 142 | 215.5 |
| 60 | 18-2 | 82 | 3 | 17 | 117.0 | 72 | 104.7 | 84 | 18-8 | 194 | 3 | 17 | 262.8 | 180 | 245.6 |
| 60 | 18-2 | 64 | 3½ | 17 | 108.3 | 54 | 93.9 | 84 | 18-8 | 150 | 3½ | 17 | 240.2 | 142 | 228.7 |
| 60 | 19-2 | 82 | 3 | 18 | 123.8 | 72 | 110.8 | 84 | 19-8 | 194 | 3 | 18 | 278.1 | 180 | 259.9 |
| 60 | 19-2 | 64 | 3½ | 18 | 114.6 | 54 | 99.3 | 84 | 19-8 | 150 | 3½ | 18 | 254.1 | 142 | 242.0 |
| 60 | 20-2 | 82 | 3 | 19 | 130.5 | 72 | 116.8 | 84 | 20-8 | 194 | 3 | 19 | 293.3 | 180 | 274.1 |
| 60 | 20-2 | 64 | 3½ | 19 | 120.8 | 54 | 104.7 | 84 | 20-8 | 150 | 3½ | 19 | 268.0 | 142 | 255.2 |
| 60 | 21-2 | 82 | 3 | 20 | 137.3 | 72 | 122.8 | 84 | 21-8 | 194 | 3 | 20 | 308.5 | 180 | 288.3 |
| 60 | 21-2 | 64 | 3½ | 20 | 127.1 | 54 | 110.1 | 84 | 21-8 | 150 | 3½ | 20 | 281.9 | 142 | 268.4 |
| 66 | 15-4 | 110 | 3 | 14 | 126.8 | 98 | 114.6 | 90 | 16-10 | 224 | 3 | 15 | 266.9 | 210 | 251.8 |
| 66 | 15-4 | 84 | 3½ | 14 | 115.0 | 74 | 103.1 | 90 | 16-10 | 176 | 3½ | 15 | 247.4 | 168 | 237.3 |
| 66 | 16-4 | 110 | 3 | 15 | 135.6 | 98 | 122.6 | 90 | 17-10 | 224 | 3 | 16 | 284.4 | 210 | 268.2 |
| 66 | 16-4 | 84 | 3½ | 15 | 123.0 | 74 | 110.3 | 90 | 17-10 | 176 | 3½ | 16 | 263.6 | 168 | 252.8 |
| 66 | 17-4 | 110 | 3 | 16 | 144.5 | 98 | 130.6 | 90 | 18-10 | 224 | 3 | 17 | 301.9 | 210 | 284.7 |
| 66 | 17-4 | 84 | 3½ | 16 | 131.0 | 74 | 117.5 | 90 | 18-10 | 176 | 3½ | 17 | 279.8 | 168 | 268.3 |
| 66 | 18-4 | 110 | 3 | 17 | 153.4 | 98 | 138.6 | 90 | 19-10 | 224 | 3 | 18 | 319.4 | 210 | 301.2 |
| 66 | 18-4 | 84 | 3½ | 17 | 139.1 | 74 | 124.7 | 90 | 19-10 | 176 | 3½ | 18 | 296.0 | 168 | 283.8 |
| 66 | 19-4 | 110 | 3 | 18 | 162.3 | 98 | 146.6 | 90 | 20-10 | 224 | 3 | 19 | 336.9 | 210 | 317.7 |
| 66 | 19-4 | 84 | 3½ | 18 | 147.1 | 74 | 131.9 | 90 | 20-10 | 176 | 3½ | 19 | 312.2 | 168 | 299.3 |
| 66 | 20-4 | 110 | 3 | 19 | 171.1 | 98 | 154.6 | 90 | 21-10 | 224 | 3 | 20 | 354.4 | 210 | 334.1 |
| 66 | 20-4 | 84 | 3½ | 19 | 155.1 | 74 | 139.0 | 90 | 21-10 | 176 | 3½ | 20 | 328.4 | 168 | 314.9 |

* This table abridged from tables on pages 23, 24, 25 and 26, and arranged according to diameter of boilers.
† Rating adpoted by the N. E. Boiler Mfrs.' Association Oct. 31, 1907.




**Plan and Sections of Horizontal Return Tubular Boiler Setting with Over-hanging Front. Used in connection with table on opposite page.**

# HORIZONTAL RETURN TUBULAR BOILERS WITH OVERHANGING FRONTS

## GENERAL MEASUREMENTS OF BOILERS AND SETTINGS.

| Dimensions of Boiler. | | | | | | | | | | | | Furnace | | | | Brick Setting. | | | | | | | | | | | Miscellaneous. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of boiler | Length of boiler over all* | Length of tubes | Length of dry sheet | Size of smoke opening | Size of nozzles | Height of nozzles | Front nozzle location | Rear nozzle location | Diameter of dome | Height of dome | Location of dome | Length of furnace † | Width of furnace † | Floor line to top of grate | Top of grate to under side of boiler | Length over all | Width over all | Height of side and rear walls § | Height of front wall | Floor line to under side of boiler | Height of boiler, floor line to top of shell | Center to center of boilers in battery | Number of common bricks single setting | Number of fire bricks furnace lined to bridge wall | Number of fire bricks, entire furnace lined | Additional no. of common bricks per foot of length | Number of common bricks for each boiler after the first | Additional number of common bricks for each boiler after the first, per foot of length | Width of cast iron front | Diam. of stack required | Height of stack required | Weight of bare boiler | Weight of boiler with fittings |
| A | B | C | D | | E | F | G | H | J | K | L | M | N | O | P | Q | R | S | T | V | W | | | | | | | | | | | | |
| in. | ft. in. | ft. | in. | in. | in. | in. | in. | in. | in. | in. | ft. in. | in. | in. | ft.in. | ft.in. | ft.in. | ft.in. | ft. in. | ft. in. | ft. in. | ft. in. | ft.in. | | | | | | | ft.in. | in. | ft. | lbs. | lbs. |
| 24 | 8-10 | 8 | 10 | 6x10 | 3 Fl. | 2 | 38¼ | 33¼ | 12 | 16 | 4-5 | 25 | 19 | 1-6 | 1-6 | 12-2 | 6-6 | 5-9 | 5-9 | 3–0 | 5-0½ | 4-2 | ‡ 6500 | 375 | 800 | 620 | 3500 | 330 | 3-0 | 12 | 40 | 1400 | 2500 |
| 30 | 11-0 | 10 | 12 | 8x16 | 3 Fl. | 2 | 40¼ | 33¼ | 16 | 20 | 5-6 | 31 | 25 | 1-10 | 1-8 | 14-2 | 7-0 | 6-7 | 6-7 | 3-6 | 6-0½ | 4-8 | ‡ 9000 | 450 | 1000 | 640 | 4800 | 340 | 3-6 | 18 | 50 | 2250 | 4000 |
| 36 | 11-0 | 10 | 12 | 8x20 | 3 Fl. | 2 | 40¼ | 33¼ | 18 | 20 | 5-6 | 37 | 31 | 1-11 | 1-8 | 14-2 | 7-6 | 7-0 | 7-2 | 3-7 | 6-7½ | 5-2 | ‡11000 | 525 | 1125 | 660 | 5900 | 350 | 4-3 | 20 | 50 | 3600 | 6000 |
| 42 | 13-0 | 12 | 12 | 8x26 | 3 Fl. | 2 | 40¼ | 33¼ | 20 | 24 | 6-6 | 43 | 37 | 2-2 | 1-11 | 16-2 | 8-0 | 7-9 | 8-5 | 4–1 | 7-7⅜ | 5-8 | ‡13000 | 630 | 1300 | 680 | 7000 | 360 | 4-9 | 24 | 50 | 5000 | 7900 |
| 48 | 16-2 | 15 | 14 | 10x32 | 4 | 6 | 48¼ | 33¼ | 24 | 30 | 8-1 | 49 | 43 | 2-2 | 1-11 | 19-2 | 8-6 | 8-1 | 8-11 | 4-1 | 8-1⅜ | 6-2 | ‡16000 | 820 | 1525 | 710 | 8500 | 370 | 5-3 | 27 | 60 | 8000 | 12000 |
| 54 | 16-2 | 15 | 14 | 10x44 | 4 | 6 | 48¼ | 33¼ | 24 | 30 | 8-1 | 55 | 49 | 2-2 | 2-2 | 19-2 | 9-0 | 8-9 | 9-6 | 4–4 | 8-10¾ | 6-8 | 16700 | 886 | 1650 | 730 | 8900 | 380 | 5-8 | 30 | 60 | 9500 | 14000 |
| 60 | 17-2 | 16 | 14 | 10x54 | 4 | 6 | 48¼ | 33¼ | 30 | 36 | 8-7 | 61 | 55 | 2-3 | 2-1 | 20-2 | 9-6 | 9-1 | 10-0 | 4–4 | 9-5 | 7-2 | 18200 | 950 | 1900 | 760 | 9700 | 400 | 6-3 | 33 | 70 | 12500 | 17500 |
| 66 | 17-4 | 16 | 16 | 12x60 | 5 | 6¼ | 50¾ | 33¼ | 36 | 42 | 8-8 | 67 | 61 | 2-3 | 2-3 | 20-2 | 10-0 | 9-8 | 10-8 | 4–6 | 10-1 | 7-8 | 20600 | 1080 | 2100 | 830 | 11300 | 450 | 6-8 | 36 | 70 | 15500 | 21500 |
| 72 | 19-6 | 18 | 18 | 14x66 | 6 | 6¼ | 52¾ | 33¼ | 42 | 42 | 9-9 | 73 | 67 | 2-3 | 2-3 | 22-2 | 10-6 | 10-0 | 11-2 | 4–6 | 10-7 | 8-2 | 23000 | 1400 | 2500 | 860 | 12800 | 460 | 7-2 | 42 | 70 | 20800 | 28000 |
| 78 | 19-8 | 18 | 20 | 16x72 | 6 | 7¼ | 54¾ | 33¼ | 42 | 42 | 9-10 | 79 | 73 | 2-6 | 2-6 | 22-2 | 11-0 | 10-10 | 12-7 | 5-0 | 11-7 | 8-8 | 24100 | 1500 | 2625 | 880 | 14800 | 470 | 8-6 | 44 | 70 | 25800 | 33700 |
| 84 | 21-8 | 20 | 20 | 16x78 | 7 | 7¼ | 54¾ | 33¼ | 42 | 42 | 10-10 | 85 | 79 | 2-6 | 2-6 | 24-2 | 11-6 | 11-3 | 12-10 | 5–0 | 12-1 | 9-2 | 27660 | 1700 | 2850 | 930 | 17000 | 485 | 9-0 | 48 | 80 | 30500 | 39500 |
| 90 | 21-10 | 20 | 22 | 18x84 | 7 | 7¼ | 56¾ | 33¼ | 42 | 48 | 10-11 | 91 | 85 | 2-6 | 2-6 | 24-2 | 12-0 | 11-8 | 13-4 | 5–0 | 12-7¼ | 9-8 | 29800 | 1850 | 3050 | 980 | 19500 | 500 | 9-6 | 50 | 100 | 36000 | 46000 |
| 96 | 21-10 | 20 | 22 | 18x92 | 8 | 7¼ | 56¾ | 33¼ | 42 | 48 | 10-11 | 97 | 91 | 2-6 | 2-6 | 24-2 | 12-6 | 12-1 | 13-10 | 5–0 | 13-1¼ | 10-2 | 32200 | 2000 | 3400 | 1040 | 22000 | 520 | 10-0 | 52 | 100 | 42500 | 53700 |

Uptakes are 1 inch deeper than smoke opening

* For each additional foot to length of boiler add one foot to length of tubes (C), and one foot to length of setting (Q)

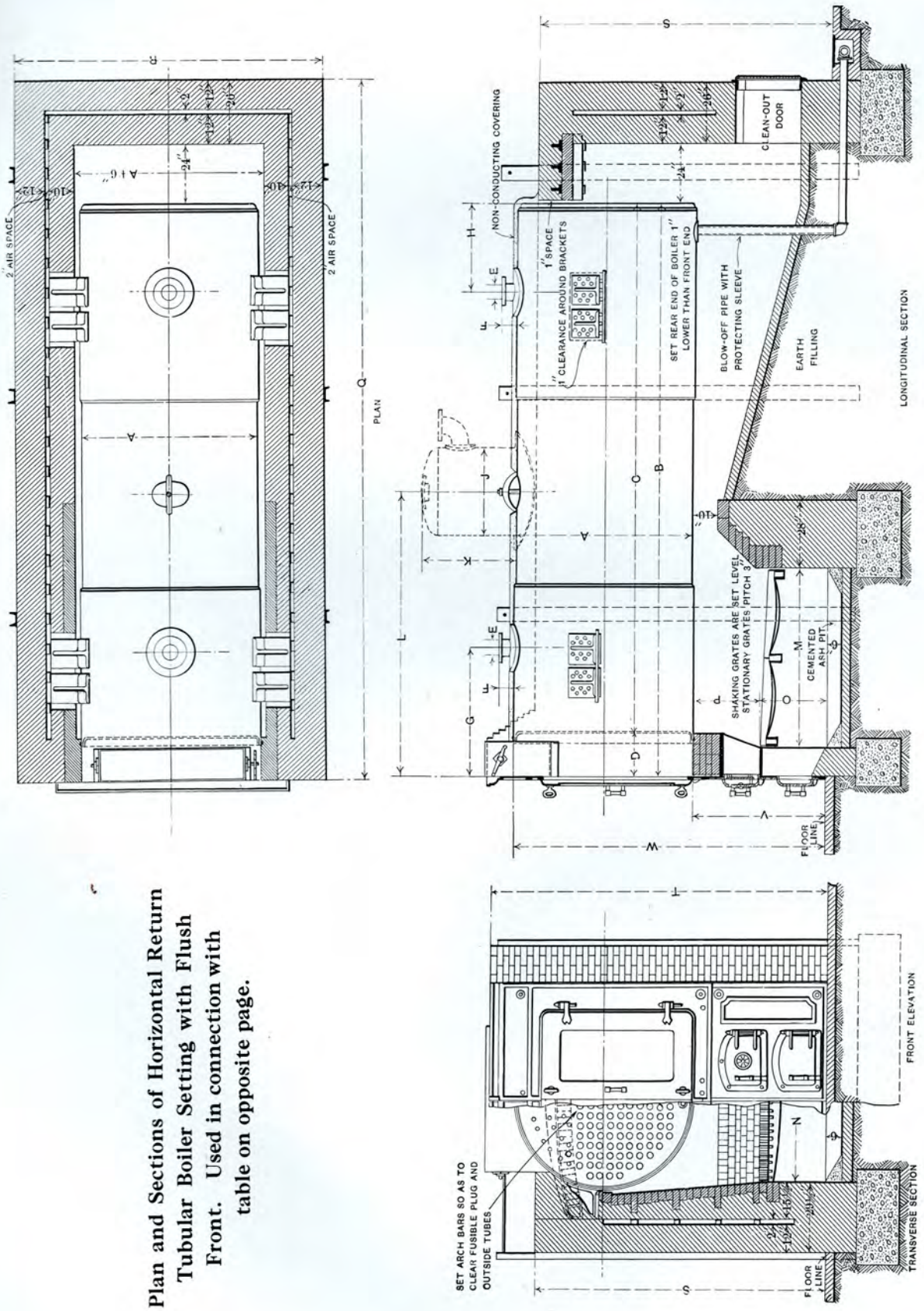
†Hartford S. B. I. & I. Co.'s standard. For further information on size of grates see pages 23, 24, 25, 26.

‡8-inch outside walls may be used for these sizes. This would lessen the total number of bricks considerably.

§If side walls are not carried as high as rear walls a less number of bricks would be used.



D. M. DILLON STEAM BOILER WORKS, FITCHBURG, MASS.




**Plan and Sections of Horizontal Return Tubular Boiler Setting with Flush Front. Used in connection with table on opposite page.**

# HORIZONTAL RETURN TUBULAR BOILERS WITH FLUSH FRONTS

## GENERAL MEASUREMENTS OF BOILERS AND SETTINGS

| Dimensions of Boiler. | | | | | | | | | | | | Furnace. | | | | Brick Setting. | | | | | | | | | | | | Miscellaneous. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of boiler | Length of boiler over all * | Length of tubes | Length of dry sheet | Size of smoke opening | Size of nozzles | Height of nozzles | Front nozzle location | Rear nozzle location | Diameter of dome | Height of dome | Location of dome | Length of furnace † | Width of furnace † | Floor line to top of grate | Top of grate to under side of boiler | Length over all | Width over all | Height of side and rear walls ‡ | Height of front wall | Floor line to under side of boiler | Height of boiler, floor line to top of shell | Center to center of boilers in battery | Number of common bricks, single setting | Number of fire bricks. Furnace lined to bridge wall | Number of fire bricks, entire furnace lined | Additional no. of common bricks, per foot of length | Number of common bricks for each boiler after the first | Additional number of common bricks for each boiler after the first, per foot of length | Width of cast-iron front | Diameter of stack required | Height of stack required | Weight of bare boiler | Weight of boiler with fittings |
| A | B | C | D | | E | F | G | H | J | K | L | M | N | O | P | Q | R | S | T | V | W | | | | | | | | | | | | |
| in. | ft. in. | ft. | in. | in. | in. | in. | in. | in. | in. | in. | ft. in. | in. | in. | ft.in. | ft.in. | ft. in. | ft.in | ft. in. | ft. in | ft. in. | ft. in. | ft.in. | | | | | | | ft in. | in. | ft. | lbs. | lbs. |
| 24 | 8-10 | 8 | 10 | 6x10 | 3 Fl. | 2 | 38½ | 33½ | 12 | 16 | 4-5 | 25 | 19 | 1-4 | 1-2 | 13-0 | 6-6 | 5-3 | 5-3 | 2-6 | 4-6½ | 4-2 | §7000 | 400 | 825 | 530 | 3750 | 285 | 3-0 | 12 | 40 | 1400 | 2600 |
| 30 | 11-0 | 10 | 12 | 8x16 | 3 Fl. | 2 | 40½ | 33½ | 16 | 20 | 5-6 | 31 | 25 | 1-4 | 1-2 | 15-2 | 7-0 | 5-7 | 5-7 | 2-6 | 5-0½ | 4-8 | §9600 | 480 | 1030 | 550 | 5150 | 295 | 3-6 | 18 | 50 | 2250 | 4200 |
| 36 | 11-0 | 10 | 12 | 8x20 | 3 Fl. | 2 | 40½ | 33½ | 18 | 20 | 5-6 | 37 | 31 | 1-11 | 1-8 | 15-2 | 7-6 | 7-0 | 7-3 | 3-7 | 6-7½ | 5-2 | §11700 | 565 | 1165 | 660 | 6300 | 350 | 4-3 | 20 | 50 | 3600 | 6250 |
| 42 | 13-0 | 12 | 12 | 8x26 | 3 Fl. | 2 | 40½ | 33½ | 20 | 24 | 6-6 | 43 | 37 | 2-2 | 1-10 | 17-2 | 8-0 | 7-8 | 8-5 | 4-0 | 7-6¾ | 5-8 | §13700 | 660 | 1330 | 680 | 7400 | 360 | 4-6 | 24 | 50 | 5000 | 8350 |
| 48 | 16-2 | 15 | 14 | 10x32 | 4 | 6 | 48½ | 33½ | 24 | 30 | 8-1 | 49 | 43 | 2-2 | 1-10 | 20-4 | 8-6 | 8-0 | 9-0 | 4-0 | 8-0¾ | 6-2 | §16700 | 860 | 1565 | 710 | 8900 | 370 | 5-3 | 27 | 60 | 8000 | 12550 |
| 54 | 16-2 | 15 | 14 | 10x44 | 4 | 6 | 48½ | 33½ | 24 | 30 | 8-1 | 55 | 49 | 2-2 | 2-2 | 20-4 | 9-0 | 8-9 | 9-6 | 4-4 | 8-10¾ | 6-8 | 17600 | 990 | 1750 | 730 | 9400 | 380 | 5-8 | 30 | 60 | 9500 | 14750 |
| 60 | 17-2 | 16 | 14 | 10x54 | 4 | 6 | 48½ | 33½ | 30 | 36 | 8-7 | 61 | 55 | 2-3 | 2-1 | 21-4 | 9-6 | 9-1 | 10-5 | 4-4 | 9-5 | 7-2 | 19100 | 1140 | 2090 | 760 | 10200 | 400 | 6-3 | 33 | 70 | 12500 | 18350 |
| 66 | 17-4 | 16 | 16 | 12x60 | 5 | 6½ | 50½ | 33½ | 36 | 42 | 8-8 | 67 | 61 | 2-3 | 2-3 | 21-6 | 10-0 | 9-8 | 10-11 | 4-6 | 10-1 | 7-8 | 21600 | 1290 | 2310 | 830 | 11900 | 450 | 7-5 | 36 | 70 | 15500 | 22450 |
| 72 | 19-6 | 18 | 18 | 14x66 | 6 | 6½ | 52½ | 33½ | 42 | 42 | 9-9 | 73 | 67 | 2-3 | 2-3 | 23-8 | 10-6 | 10-0 | 11-6 | 4-6 | 10-7 | 8-2 | 24000 | 1650 | 2750 | 860 | 13400 | 460 | 7-10 | 42 | 70 | 20800 | 29000 |
| 78 | 19-8 | 18 | 20 | 16x72 | 6 | 7¼ | 54½ | 33½ | 42 | 42 | 9-10 | 79 | 73 | 2-6 | 2-6 | 23-10 | 11-0 | 10-10 | 12-7 | 5-0 | 11-7 | 8-8 | 25600 | 1900 | 3025 | 880 | 15500 | 470 | 8-6 | 44 | 70 | 25800 | 34900 |
| 84 | 21-8 | 20 | 20 | 16x78 | 7 | 7¼ | 54½ | 33½ | 42 | 42 | 10-10 | 85 | 79 | 2-6 | 2-6 | 25-10 | 11-6 | 11-3 | 13-0 | 5-0 | 12-1 | 9-2 | 29460 | 2100 | 3250 | 930 | 17800 | 485 | 9-1 | 48 | 80 | 30500 | 40900 |
| 90 | 21-10 | 20 | 22 | 18x84 | 7 | 7¼ | 56½ | 33½ | 42 | 48 | 10-11 | 91 | 85 | 2-6 | 2-6 | 26-0 | 12-0 | 11-8 | 13-4 | 5-0 | 12-7¼ | 9-8 | 31800 | 2300 | 3500 | 980 | 20400 | 500 | 9-6 | 50 | 100 | 36000 | 48000 |
| 96 | 21-10 | 20 | 22 | 18x92 | 8 | 7¼ | 56½ | 33½ | 42 | 48 | 10-11 | 97 | 91 | 2-6 | 2-6 | 26-0 | 12-6 | 12-1 | 13-10 | 5-0 | 13-1¼ | 10-2 | 34500 | 2500 | 3900 | 1040 | 23000 | 520 | 10-0 | 52 | 100 | 42500 | 55900 |

Uptakes are 1″ deeper than smoke opening.

* For each additional foot to length of boiler add one foot to length of tubes (C), and one foot to length of setting (Q).

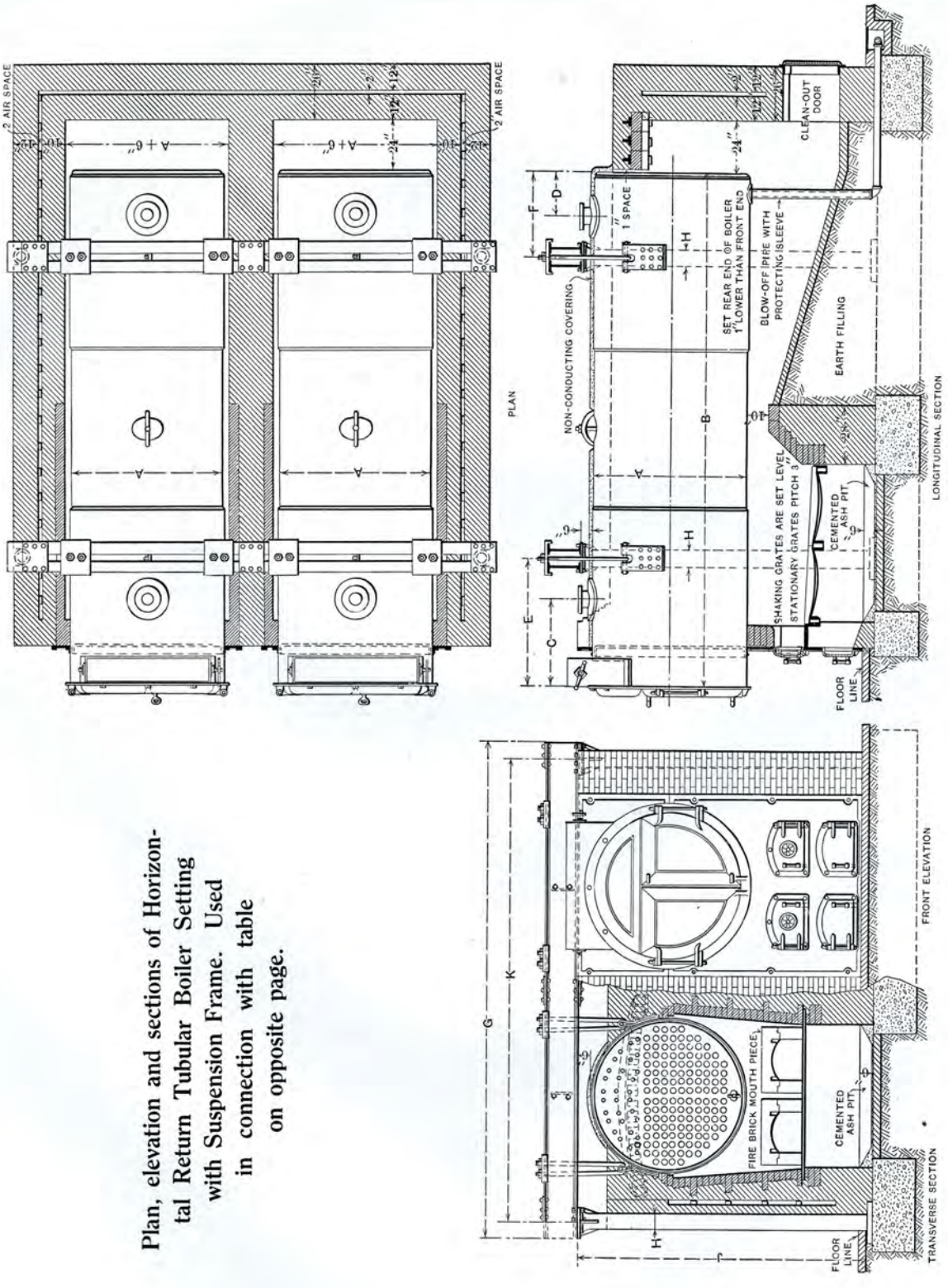
† Hartford S. B. I. & I. Co.'s Standard. For further information on size of grates see pages 23, 24, 25 and 26.

‡ If side walls are not carried as high as rear walls a less number of bricks would be used.

§ 8″ outside walls may be used for these sizes; this would lessen the total number of bricks considerably.



D. M. DILLON STEAM BOILER WORKS, FITCHBURG, MASS.




**Plan, elevation and sections of Horizontal Return Tubular Boiler Setting with Suspension Frame. Used in connection with table on opposite page.**

# HORIZONTAL RETURN TUBULAR BOILERS WITH SUSPENSION FRAMES

## GENERAL MEASUREMENTS FOR CONSTRUCTION.

| Diameter of boiler | Length over all | Location of nozzles | | Location of brackets | | SIZE OF GIRDERS FOR SUSPENSION | | | | | | | | | SIZE OF CAST IRON COLUMNS FOR | | | | | | | SIZE OF I-BEAMS FOR COLUMNS | | | | | | | Cen. to cen. of boilers in battery if more than two are used. | Total weight of one boiler full of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | One boiler | | | | | Two boilers | | | | One boiler | | | | Two boilers | | | One boiler | | | | Two boilers | | | | |
| | | | | | | I-Beams | | | Channels† | | I-Beams | | | Channels† | | | | | | | | | | | | | | | | |
| | | Front | Rear | Front | Rear | Depth | Weight | Length | Depth | Weight | Depth | Weight | Length | Depth | Weight | Outside diam. | Length | Thickness | Cen. to cen | Outside diam. | Thickness | Cen. to cen. | Depth | Weight | Length | Cen. to cen | Depth | Weight | Cen to cen. | | |
| A | B | C | D | E | F | | Lbs. | *G | | Lbs. | | Lbs. | *G | | Lbs. | H | J | | *K | H | | *K | | Lbs. | | | | Lbs. | *K | | |
| in. | ft. in. | in. | in. | in. | in. | in. | per ft. | ft. in | in. | per ft. | in. | per ft. | ft.in. | in. | per ft. | in. | ft. in. | in. | ft. in. | in. | in. | ft. in. | in. | per ft. | ft. in. | ft. in. | in. | per ft. | ft. in. | ft. in. | Pounds |
| 30 | 11-0 | 34¼ | 21¼ | 46 | 34 | 4 | 7.5 | 7-5 | 4 | 5.25 | 6 | 12.25 | 12-1 | 7 | 9.75 | 4 | 6-11 | ½ | 6-8 | 5 | ¾ | 11-3 | 5 | 9.75 | 6-9¾ | 6-8 | 6 | 12.25 | 11-3 | 5-2 | 6600 |
| 36 | 11-0 | 34¼ | 21¼ | 46 | 34 | 4 | 7.5 | 7-11 | 4 | 6.25 | 7 | 15. | 13-1 | 8 | 11.25 | 4 | 7-6 | ½ | 7-2 | 5 | ¾ | 12-3 | 5 | 9.75 | 7-4¾ | 7-2 | 6 | 12.25 | 12-3 | 5-8 | 9700 |
| 42 | 13-0 | 34¼ | 21¼ | 48 | 36 | 5 | 9.75 | 8-6 | 6 | 8. | 8 | 18. | 14-1 | 10 | 15. | 4 | 8-6 | ½ | 7-8 | 5 | ¾ | 13-3 | 5 | 9.75 | 8-4¾ | 7-8 | 6 | 12.25 | 13-3 | 6-2 | 13900 |
| 48 | 16-2 | 36¼ | 21¼ | 50 | 36 | 6 | 12.25 | 8-11 | 6 | 10.5 | 9 | 21. | 15-2 | 12 | 20.5 | 5 | 9-0 | ¾ | 8-1 | 6 | ¾ | 14-2 | 6 | 12.25 | 8-10½ | 8-1 | 6 | 12.25 | 14-2 | 6-8 | 21500 |
| 54 | 16-2 | 36¼ | 21¼ | 50 | 36 | 6 | 12.25 | 9-5 | 8 | 11.25 | 10 | 25. | 16-2 | 12 | 25. | 5 | 9-9 | ¾ | 8-7 | 6 | ¾ | 15-2 | 6 | 12.25 | 9-7½ | 8-7 | 7 | 15. | 15-2 | 7-2 | 26000 |
| 60 | 17-2 | 36¼ | 21¼ | 51 | 37 | 7 | 15. | 10-1 | 8 | 11.25 | 12 | 31.5 | 17-2 | 15 | 33. | 5 | 10-3 | ¾ | 9-1 | 6 | ¾ | 16-2 | 7 | 15. | 10-1½ | 9-1 | 8 | 18. | 16-2 | 7-8 | 33500 |
| 66 | 17-4 | 38¼ | 21¼ | 54 | 38 | 7 | 15. | 10-6 | 9 | 13. | 12 | 40. | 18-2 | 15 | 40. | 6 | 10-11 | ¾ | 9-6 | 6 | 1 | 17-2 | 7 | 15. | 10-9½ | 9-6 | 8 | 18. | 17-2 | 8-2 | 40500 |
| 72 | 19-6 | 40¼ | 21¼ | 56 | 40 | 8 | 18. | 11-0 | 10 | 20. | 15 | 42. | 19-3 | 15 | 50. | 6 | 11-5 | ¾ | 10-0 | 8 | ⅞ | 18-0 | 8 | 18. | 11-3½ | 10-0 | 10 | 25. | 18-0 | 8-8 | 53000 |
| 78 | 19-8 | 42¼ | 21¼ | 59 | 42 | 9 | 21. | 11-6 | 12 | 20.5 | 15 | 60. | 20-3 | | | 6 | 12-5 | 1 | 10-6 | 8 | ⅞ | 19-0 | 8 | 18. | 12-3½ | 10-6 | 10 | 25. | 19-0 | 9-2 | 63000 |
| 84 | 21-8 | 42¼ | 21¼ | 59 | 48 | 10 | 25. | 12-3 | 12 | 25. | 18 | 55. | 21-3 | | | 6 | 12-11 | 1 | 11-0 | 8 | 1 | 20-0 | 10 | 25. | 12-9¼ | 11-0 | 10 | 35. | 20-0 | 9-8 | 76500 |
| 90 | 21-10 | 44¼ | 21¼ | 62 | 48 | 10 | 30. | 12-9 | 12 | 30 | 20 | 65. | 22-3 | | | 6 | 13-5 | 1 | 11-6 | 8 | 1 | 21-0 | 10 | 25. | 13-3¼ | 11-6 | 12 | 40. | 21-0 | 10-2 | 88000 |
| 96 | 21-10 | 44¼ | 21¼ | 62 | 48 | 12 | 31.5 | 13-1 | 15 | 33. | 20 | 75. | 23-4 | | | 8 | 13-11 | 1 | 11-10 | 10 | 1 | 21-10 | 10 | 25. | 13-9¼ | 11-10 | 12 | 40. | 21-10 | 10-8 | 101000 |

For dimensions of boilers and settings see tables on pages 29 and 31.
* Letters "G" and "K" signify dimension for one or two boilers, as the case may be.
† Length of channels same as "G."

# Manning Boilers.

THE first boiler of the Manning type (150 H. P. unit) was designed by Capt. C. H. Manning, superintendent of the Amoskeag Mfg. Co., Manchester, N. H.,* and was placed in operation in the plant of that company in January, 1883. Thus this Manning boiler is twenty-five years old and is doing duty today at 110 ponuds pressure, 10 pounds more than the pressure for which it was originally intended. The expenditure for repairs on this boiler since its installation has been less than $100, the greatest expense having been incurred by the taking out of a number of tubes, not because of defects, but to see how much they had deteriorated. Contrary to the theory of most boiler experts, the greatest deterioration was at the lower tube sheet, the tubes above the water line showing very slight wear. The first battery of sixteen boilers, built under the direction of Capt. C. H. Manning, was started October 1, 1883, and fifteen of them are in service today, the sixteenth having been taken out, repaired and sold. The total expense per boiler, including grates in this plant, up to the present time (25 years' usage) has been $375, which is a yearly expense of $15 per boiler. What other type of boiler can show such a record?

Every great invention is the result of gradual evolution, and the Manning boiler of the present day is no exception. The first boilers of this type were built for 100 pounds working pressure, with low fireboxes, thin reverse flanges, were hand riveted and little attention was paid to the minor details, the aggregate of which constitute perfection.

Experimental as these first boilers were, they conclusively demonstrated that the principle of the boiler was correct and that great possibilities lay in the development of its application. The correctness of its construction and design particularly adapt the Manning boiler for the extremely high pressures of the present time. The tube layouts have been carefully calculated so that the proper ratio exists between the grate and heating surfaces. The length of the tubes has been so proportioned to their diameter that practically all the heat units of combustion are absorbed.

With the old style vertical boiler, it was almost impossible to clean the crown sheet and the water leg, for the simple reason that they were inaccessible. With the Manning boiler of today, the case is entirely different. The outer water leg plate is carried well above the firebox head, and a number of handholes placed on a line with the crown sheet. The tubes are placed in straight rows with one-inch spaces between them, and two additional extra wide central spaces run at right angles to each other, thus allowing every part of the crown sheet to be thoroughly cleaned. When the feed water contains excessive amounts of lime, magnesia or other foreign substances, a number of extra handholes, the invention of Capt. C. H. Manning (see page 39), are put in the shell opposite each tube aisle. By means of these, the trouble resulting from the accumulation of sediment, scale, etc., on the crown sheet is entirely obviated. Around the bottom of water leg and over fire door, handholes are also placed. A cleaning chain, also the

*All the steam plants of this company are equipped with the Manning type of boiler, aggregating 23100 H. P.

invention of Capt. C. H. Manning, is placed inside the water leg, by means of which any sediment may be removed.

The cost of repairs on the Manning boiler is less than on any other type, and, under ordinary conditions, if properly operated, there will be no expenditure for repairs in ten or more years. In the case of a brick set boiler, it is always necessary, no matter how much care is exercised, to repair the setting once a year, and the masonry around the doors oftener. Thus it is obvious that the expense for repairs to brick set boilers would equal, in from ten to fifteen years, the first cost of boiler. With an internally fired boiler, the economy remains constant, while with a brick set boiler, the openings in the setting allow the cold air to mix with the heat of combustion, thereby cooling the gases and rendering the boiler less efficient.

The Manning boiler represents, without doubt, the maximum of safety in construction. It is so designed that the strongest parts are subjected to the greatest strain, and, as the outside firebox and shell plates do not come in contact with the fire, they may be as thick as required, while the necessary strength for the thinner furnace plates is gained by stay-bolting. There is, of course, no danger of tube explosions in any fire tube boiler, this being one of the undesirable features of water tube boilers, with which tube explosions are of frequent occurrence. We can say of the Manning type of boiler, as of the horizontal tubular, that no boiler of this type, constructed with butt-strap joints, has exploded. This record means that at last, after many years of experimenting with the so-called safety boilers, whose name, in most cases, was the only safety feature about them (see page 63), a practical safety boiler has appeared, and its constantly increasing installation shows that the thankful boiler users appreciate the time and money spent to bring about this perfection of safety.

The Manning type of boiler occupies less space per horse power than any other type of boiler designed on correct principles, and consequently, a greater amount of horse power may be installed in a given floor space. A single boiler of 250 H. P. requires but a floor space of 8 feet in diameter. For further information on horse power, see pages 50 and 51.

The great advantage that the Manning boiler has over any other type is its ability to furnish superheated steam without an expensive superheater. This advantage explains the tremendous demand for this type of boiler in modern steam plants, where high pressure dry steam is required, and especially where turbines are used. Ten years ago, very little attention was paid to superheated steam and its value was only recognized in this country recently, although the French and Germans have made use of it for a number of years, to great advantage. The amount of superheat ordinarily present in a Manning boiler is from 25° to 35°, although this temperature can be increased a great deal by simply lowering the water line. When turbines are used, it is often desirable to have a high degree of superheat, and this is obtained in the Manning type of boiler by increasing the length of the tubes. On all other types of boilers, to obtain dry steam, separate superheaters must be installed, which require not only a high first cost, but also a large expenditure from time to time for repairs, made necessary by the rapid deterioration of the superheaters. Superheated steam obtained under such conditions is produced at the expense of economy, rather than effecting the saving for which it was intended. More information on superheated steam will be found on pages 53 and 54.

As regards economy, an examination of the tests shown on page 37 will prove that this type of boiler is equally efficient as the "time-honored horizontal tubular boiler." The question very often arises as to why the Manning boiler should be so efficient when the gases travel but a short distance and in straight lines. A moment's consideration will explain. The tubes are of small diameter and of such length that the heat units are practically all removed when they enter the uptake, as shown by the temperature. See tests on page 37. These tests prove conclusively that the Manning boiler is as economical as any type of boiler in use at the present time.

In every brick set boiler, there is a large percentage of heat lost by radiation. This amount is estimated by able engineers at about 5%. With the Manning boiler, there is no brickwork, and consequently no heat loss by radiation. This type of boiler, on account of its construction, requires less chimney draught to burn a given amount of fuel than any other type of boiler. The gases pass directly from the combustion chamber through the tubes into the smoke bonnet, without a single turn. As every turn seriously affects the draught, it will be seen why the above statement is correct. The following are a few of the many points of excellence which clearly show the superiority of Manning boilers:

Low cost of installation; economy of fuel; good circulation; low cost of maintenance; ability to easily clean fire and water surfaces; open market for repairs; constant economy; high factor of safety; safety of tubes; simplicity; absence of baffle plates; effective heating surface; reliability; no short circuiting of gases; ability to furnish superheated steam without a superheater; absence of all brickwork, and economy of floor space.

The steel used in the shell of Manning boilers is the very best quality of Open Hearth Firebox, with a tensile strength of 55,000-65,000 pounds. The plates in the inside furnace and ogee heads are of special soft steel, with low tensile strength and high ductility, admirably adapted for the purposes for which they are used. The fire door openings are formed by flanging out the inside and outside furnace sheets and riveting them together. By this method, the rivets are protected from the fire, as shown on page 41. As the fire does not come in contact with the shell of boiler, it is possible, by using thick shell plates and placing the staybolts closely together, to build these boilers for any desirable pressure, and not a few of our Manning boilers are working under 200 pounds pressure with most excellent results.

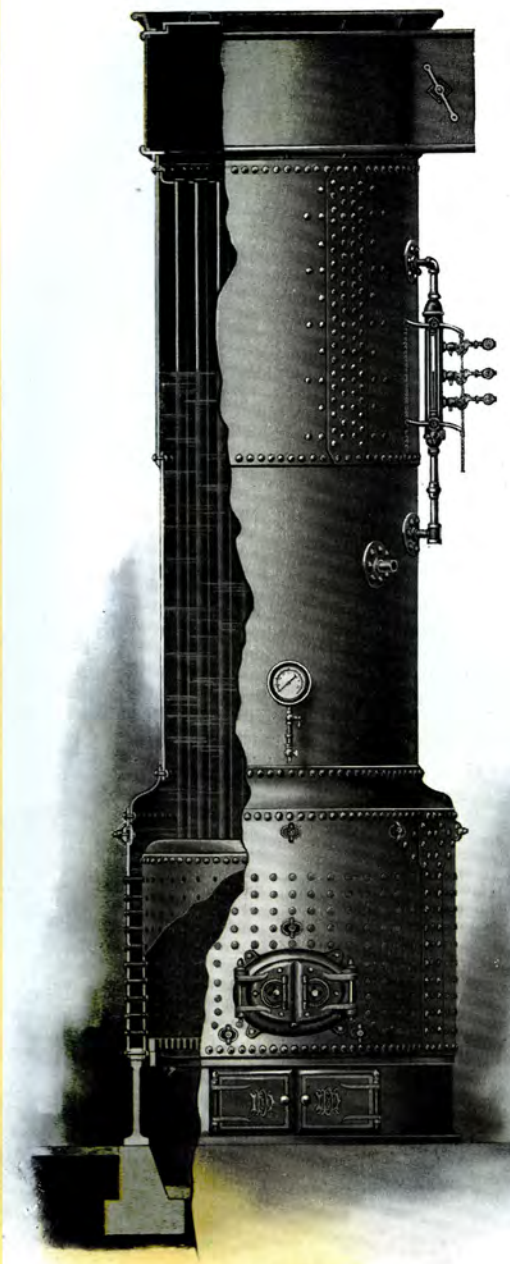
On page 37, twenty tests will be found on Manning boilers, from representative concerns and made by reputable engineers. We wish to call special attention to their very high average economy; viz., 12.30 pounds of water evaporated from and at 212° per pound of combustible. It so happens that, in a majority of these tests, the boilers were run below their rating, but tests numbers 3, 14 and 20 show what these boilers can do when burning more than 17 pounds of coal per square foot of grate per hour. We desire to call special attention to the results of tests 17, 18 and 19, made on batteries of six, seven and eight boilers, respectively.

The table on page 54, showing results obtained by lowering the water-line in an upright boiler, will be found very interesting to those who require a high degree of superheat.

## RESULTS OF MANNING BOILER TESTS

| No. | Year | Grate area, sq. ft. | Heating surface, sq. ft. | Steam pressure, lbs. | Boiler H. P. developed | Kind of coal | Coal burned per sq. ft. of grate per hour. Lbs. | Water evap. per hour per sq. ft. water heating surface from and at 212°. Lbs. | Evaporation from and at 212° | | Boiler H. P. per sq. ft. of grate. | No. sq. ft. of water heating surface per horse power. | Temperature escaping gases, degrees F. | Tested by | How fired |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Per lb. coal. Lbs. | Per lb. combustible. Lbs. | | | | | |
| 1 | Unknown | 28.3 | 1260 & 1700 | 46 | 243 | Cumberland | 13.1 | 3.2 | 11.34 | 12.29 | 8.58 | 5.18 | 427 | Barrus | Hand |
| 2 | 1897 | 33.2 | 1489 & 2154 | 153 | 123 | Cumberland | 11.7 | 2.86 | 10.94 | 11.96 | 3.72 | 12. | 520 | Barrus | Hand |
| 3 | 1894 | 28.27 | 1388 & 1869 | 123 | 194 | Pocahontas | 23.0 | 4.90 | 10.07 | 12.00 | 6.85 | 7. | 531 | Denton | Hand |
| 4 | 1894 | 28.27 | 1388 & 1869 | 123 | 126 | Pocahontas | 14.7 | 3.10 | 10.38 | 12.32 | 4.47 | 11. | 496 | Denton | Hand |
| 5 | 1894 | 28.27 | 1388 & 1869 | 156 | 95 | Pocahontas | 10.9 | 2.30 | 10.62 | 12.35 | 3.38 | 15. | 362 | Denton | Hand |
| 6 | 1894 | 28.27 | 1388 & 1869 | 142 | 98 | Cumberland | 11.0 | 2.44 | 10.89 | 11.92 | 3.47 | 14. | 380 | Dean | Hand |
| 7 | 1894 | 33.4 | 1384 & 2036 | 114 | 119 | Pocahontas | 11.3 | 2.90 | 11.19 | 11.92 | 3.57 | 11.6 | 395 | Dean | Hand |
| 8 | 1894 | 33.4 | 1492 & 2036 | 115 | 162 | Pocahontas | 15.2 | 3.69 | 10.02 | 11.83 | 4.85 | 9.2 | 439 | Dean | Hand |
| 9 | 1894 | 28.2 | 1745 = Total | 67 | 115 | Cumberland | 12.7 | 2.28* | 10.96 | 11.64 | 4.09 | 15.1* | 491 | Dean | Hand |
| 10 | 1905 | 33.2 | 1647 & 2201 | 110 | 179 | Pocahontas | 16.53 | 3.75 | 11.26 | 11.89 | 5.39 | 9.20 | 449 | Sheldon | Hand |
| 11 | 1898 | 28.25 | 1347 & 1796 | 125 | 107 | Pocahontas | 9.96 | 2.39 | 11.47 | 12.26 | 3.78 | 12.58 | 331 | Erickson | Hand |
| 12 | 1888 | 28.27 | 1260 & 1701 | 46 | 121 | Cumberland | 13.8 | 2.89 | 11.34 | 12.28 | 4.28 | 10.4 | 427 | Barrus | Hand |
| 13 | 1898 | 28.27 | 1347 & 1796 | 160 | 110 | Pocahontas | 11.2 | 2.42 | 12.09 | 12.76 | 3.88 | 12.24 | 418 | Manning | Hand |
| 14 | 1900 | 52.00 | 2498 & 3393 | 107 | 350 | Cumberland | 20.8 | 4.84 | 11.17 | 12.37 | 6.73 | 7.13 | 742 | Manning | Roney Stoker |
| 15 | 1897 | 28.30 | 1260 & 1700 | 99 | 132 | Pocahontas | 13.6 | 3.10 | 11.89 | 12.74 | 4.66 | 9.54 | 522 | Barrus | Hand |
| †16 | 1901 | 38.5 | 2174 & 2852 | 115 | 192 | Cumberland | 15.89 | 3.04 | 10.57 | 12.47 | 4.98 | 11.32 | 368 | Green | Hand |
| ‡17 | 1894 | 169.62 | 8298 & 11124 | 125 | 747 | Pocahontas | 13.71 | 3.19 | 10.80 | 13.09 | 4.40 | 11.10 | 510 | Denton | Hand |
| §18 | 1894 | 226.16 | 11064 & 14832 | 124 | 797 | Pocahontas | 10.42 | 2.48 | 11.09 | 13.41 | 3.52 | 13.88 | 467 | Denton | Hand |
| ‖19 | 1894 | 197.89 | 9681 & 12978 | 125 | 715 | Pocahontas | 11.01 | 2.55 | 10.75 | 13.02 | 3.61 | 13.53 | 460 | Denton | Hand |
| 20 | 1895 | 33.4 | 1897 & 2431 | 79 | 226 | Pocahontas | 21.56 | 4.11 | 10 83 | 11.50 | 6.77 | 8.40 | 422 | Dean | Hand |
| Average evaporation, | | | | | | | | | 10.98 | 12.30 | | | | | |

* Figured from total heating surface.
† 74″ Manning boiler, 284 2½″ x 16′ tubes, 4-foot steam space.
‡ Battery of 6 boilers.
§ Battery of 8 boilers.
‖ Battery of 7 boilers.



Ogee Ring or Reverse Flange

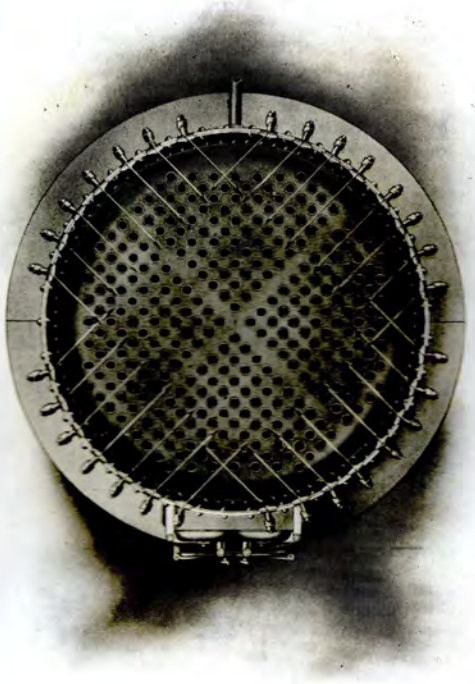
Cast-iron Base

## Manning Boiler

Sectional elevation, showing cast-iron base, Ogee ring, double fire doors and general design. Special attention is called to the Ogee ring. By our method of construction the flat surface between the upper and lower curves, which was found objectionable in the earlier types of Manning boilers, is entirely eliminated.

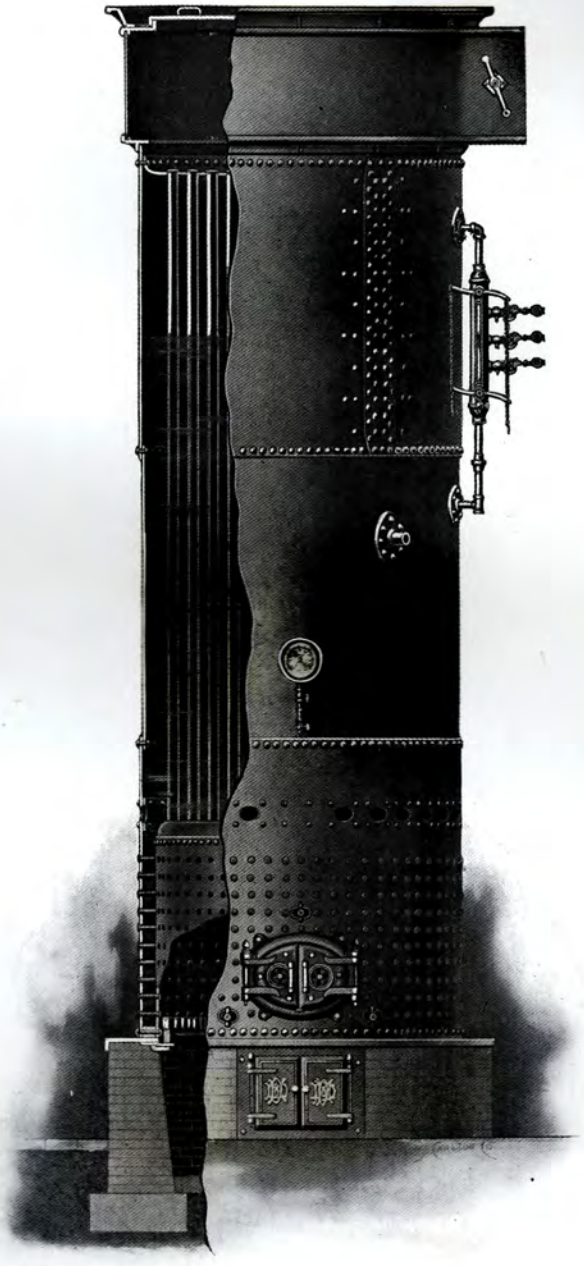
The steam opening is not shown in cut, but can be placed in top head or in shell at any desired point. By using a cast-iron base, as shown, all brickwork is eliminated, and the caulking edges of lower fire box plates made accessible.

For general dimensions of Manning boilers see page 42.



**Horizontal Section of Upright Boiler**

**Showing arrangement of handholes for cleaning crown sheet.**

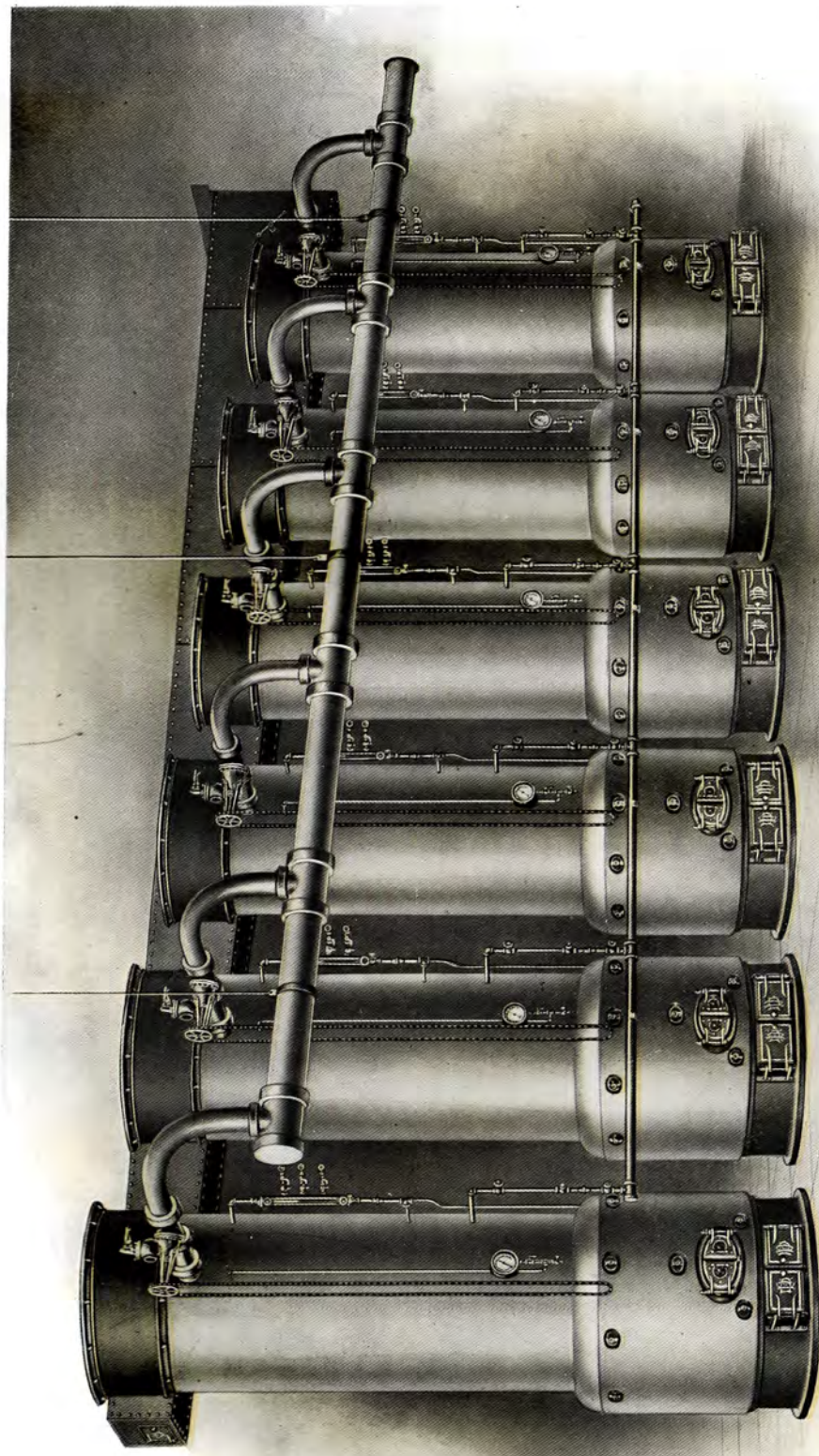


# Plain Upright Boiler

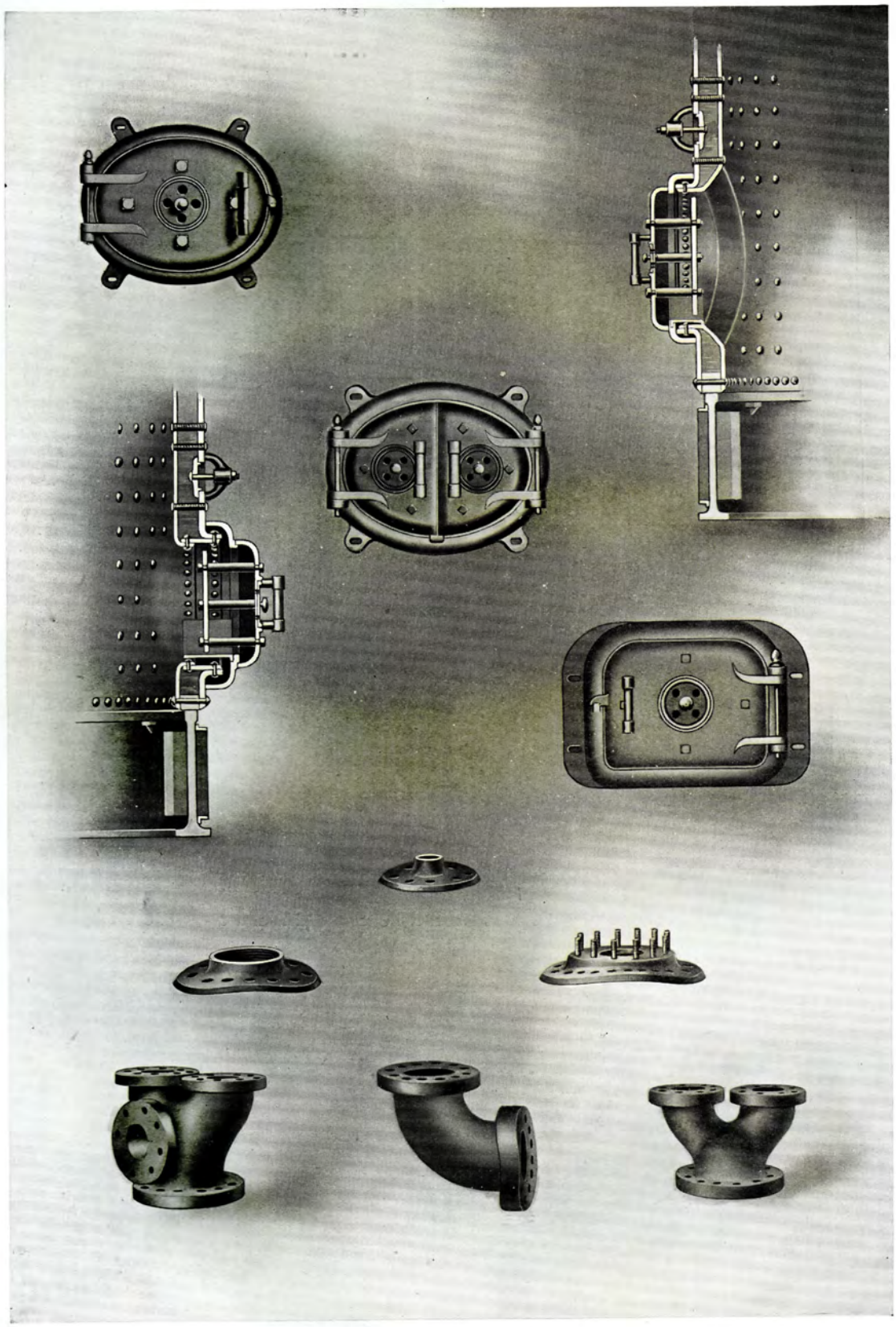
Sectional elevation showing cast-iron base plate on brickwork and general design. The steam opening is not shown in cut, but can be placed in top head or in shell at any desired point.

Special attention is called to the series of handholes in the shell, on a level with the crown sheet, to facilitate cleaning. By this arrangement access is given to every part of the crown sheet. This device is recommended in localities where the feed water contains excessive amounts of impurities.

For general dimensions of Plain Upright boilers see page 42.



**Battery of 1500 Horse Power High Pressure Manning Boilers**
Showing Complete Installation



**Details of Manning Boilers**

# GENERAL DIMENSIONS OF MANNING BOILERS.

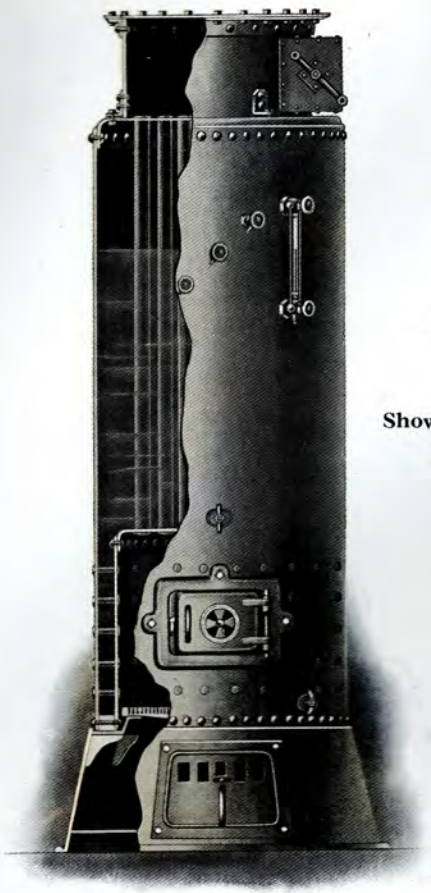
| Rating | Heating Surface | | | | Waist | Furnace | | | Tubes | | | Bonnet | | | | Base | | | | Heights | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horsepower (12sq. ft. of total heating surface per horsepower) | Water heating surface | Super-heating surface | Total heating surface | Additional heating surface per foot of tube | Diameter | Diameter of outside for 150 lbs. pressure | Diameter inside | Height | Number | Diameter | Length | Height of sheet | Height over all | Size of smoke opening | Center line of boiler to end of smoke opening | Height of cast-iron base | Height of brick base | Outside diameter of brick base | Outside dia. c. i. base (lower flange) | Bottom of water leg to end of top sheet (height of boiler) | Floor line to top of bonnet if cast-iron base is used | Floor line to top of bonnet if brick base is used |
| | Sq. ft. | Sq. ft. | Sq. ft. | Sq. ft. | Inches | In. | In. | In. | | In. | Ft | In. | In. | Inches | Ft. In. | In. | In. | In. | In. | Ft.In. | Ft. In. | Ft. In. |
| 43.5 | 395 | 128 | 523 | 42.64 | 38 | 55⅝ | 48 | 42¾ | 90 | 2 | 11 | 18 | 21 | 18x20 | 2-8½ | 21½ | 24¾ | 64 | 57¾ | 15-0 | 18-6½ | 18-9¾ |
| 60.8 | 551 | 179 | 730 | 51.37 | 44 | 61⅝ | 54 | 42¾ | 86 | 2½ | 13 | 18 | 21 | 18x24 | 2-11⅛ | 21½ | 24¾ | 70 | 63¾ | 17-0 | 20-6½ | 20-9¾ |
| 89.5 | 807 | 267 | 1074 | 66.90 | 48 | 65¾ | 58 | 45¾ | 112 | 2½ | 15 | 18 | 21 | 18x28 | 3-1⅛ | 21½ | 24¾ | 74 | 67¾ | 19-3 | 22-9½ | 23-0¾ |
| 98.7 | 889 | 296 | 1185 | 74.07 | 50 | 67¾ | 60 | 45¾ | 124 | 2½ | 15 | 18 | 21½ | 18x28 | 3-2⅛ | 21½ | 24¾ | 76 | 69¾ | 19-3 | 22-10 | 23-1¼ |
| 120.4 | 1082 | 363 | 1445 | 90.80 | 56 | 73⅞ | 66 | 45⅝ | 152 | 2½ | 15 | 24 | 27½ | 24x28 | 3-5⅛ | 21½ | 24¾ | 82 | 75¾ | 19-3 | 23-4 | 23-7¼ |
| 149.6 | 1347 | 449 | 1796 | 112.31 | 61 | 80⅛ | 72 | 57¾ | 188 | 2½ | 15 | 24 | 28 | 24x31½ | 3-6½ | 21½ | 24¾ | 88 | 82 | 20-3 | 24-4½ | 24-7¾ |
| 183.4 | 1647 | 554 | 2201 | 138.59 | 67 | 86¼ | 78 | 57¾ | 232 | 2½ | 15 | 30 | 33½ | 30x34 | 3-10 | 21½ | 24¾ | 94 | 88 | 20-3 | 24-10 | 25-1¼ |
| 223.5 | 2005 | 678 | 2683 | 169.66 | 74 | 92¼ | 84 | 60¾ | 284 | 2½ | 15 | 30 | 33½ | 30x40 | 4-2⅛ | 21½ | 25 | 100 | 94 | 20-6 | 25-1 | 25-4½ |
| 260.4 | 2332 | 793 | 3125 | 198.33 | 80 | 98⅜ | 90 | 60¾ | 332 | 2½ | 15 | 36 | 39½ | 36x40 | 4-5⅛ | 24 | 25 | 106 | 100 | 20-6 | 25-9½ | 25-10½ |
| 307.2 | 2751 | 936 | 3687 | 234.18 | 86 | 104½ | 96 | 66¾ | 392 | 2½ | 15 | 42 | 45½ | 42x40 | 4-8⅛ | 24 | 25 | 112 | 106 | 21-0 | 26-9½ | 26-10½ |
| 353.1 | 3158 | 1080 | 4238 | 270.02 | 92 | 110½ | 102 | 66¾ | 452 | 2½ | 15 | 42 | 45½ | 42x46 | 4-11⅛ | 24 | 25 | 118 | 112 | 21-0 | 26-9½ | 26-10½ |
| 389.6 | 3481 | 1195 | 4676 | 298.70 | 96 | 114⅝ | 106 | 66¾ | 500 | 2½ | 15 | 42 | 45½ | 42x54 | 5-1⅛ | 24 | 25 | 122 | 116 | 21-0 | 26-9½ | 26-10½ |

## MANNING BOILERS—continued.

## †PLAIN UPRIGHT BOILERS.

| Waist | *Thickness of Material | | | | | | | | | Details | | | | Miscellaneous | | | | ‡Outside diam. of boiler (lowest course) 150 lbs. pressure | Center line of boiler to end of smoke opening in bonnet. | Bottom of water leg to end of top sheet (height of boiler) | Floor line to top of bonnet if cast-iron base is used (extreme height) | Floor line to top of bonnet if brick base is used (extreme height) | *Thickness of shell for 150 lbs. pressure | 175 lbs. pressure | 200 lbs. pressure | Weight of boiler with fittings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Waist plates for | | | Outside furnace pl. for | | | Heads for | | | | | | | | | | | | | | | | | | | |
| Diameter | 150 lbs. pressure | 175 lbs. pressure | 200 lbs. pressure | 150 lbs. pressure | 175 lbs. pressure | 200 lbs. pressure | Inside furnace plates | 150 lbs. pressure | 175 lbs. pressure | 200 lbs. pressure | Size of feed pipe | Size of blow-off pipe | Size of safety valve | Size steam opening | Center to center of boilers in battery | Diam. of stack req. | Height of stack required | Weight of boiler with fittings | | | | | | | | |
| In. | In. | In. | In. | In. | In. | In | In. | In. | In. | In. | In. | In. | In. | In | Ft.In | In | Ft. | Lbs. | In. | Ft. In. | Ft. In. | Ft. In | Ft. In. | In. | In. | In. | Lbs |
| 38 | 5/16 | 5/16 | 5/16 | 7/16 | 1/2 | 9/16 | 5/16 | 5/16 | 7/16 | 1/2 | 1¼ | 2 | 2½ | 3 | 5-10 | 24 | 50 | 10200 | 55⅝ | 3-4½ | 15-2 | 18-8½ | 18-11¾ | 7/16 | 1/2 | 9/16 | 10000 |
| 44 | 5/16 | 5/16 | 7/16 | 7/16 | 1/2 | 9/16 | 5/16 | 5/16 | 7/16 | 1/2 | 1¼ | 2 | 3 | 3 | 6-4 | 27 | 50 | 13450 | 61⅝ | 3-7½ | 17-2 | 20-8½ | 20-11¾ | 7/16 | 1/2 | 9/16 | 13400 |
| 48 | 5/16 | 7/16 | 1/2 | 1/2 | 9/16 | 5/8 | 5/16 | 7/16 | 1/2 | 9/16 | 1¼ | 2 | 3 | 4 | 6-8 | 30 | 60 | 17500 | 65¾ | 3-9½ | 19-5 | 22-11½ | 23-2¾ | 1/2 | 9/16 | 5/8 | 19000 |
| 50 | 5/16 | 7/16 | 1/2 | 1/2 | 9/16 | 5/8 | 5/16 | 7/16 | 1/2 | 9/16 | 1¼ | 2 | 3 | 4 | 6-10 | 30 | 70 | 18900 | 67¾ | 3-10½ | 19-5 | 23-0 | 23-3¼ | 1/2 | 9/16 | 5/8 | 20500 |
| 56 | 7/16 | 1/2 | 9/16 | 9/16 | 5/8 | 11/16 | 5/16 | 1/2 | 9/16 | 5/8 | 1½ | 2 | 3½ | 4 | 7-4 | 33 | 70 | 22500 | 73⅞ | 4-1½ | 19-5 | 23-6 | 23-9¼ | 9/16 | 5/8 | 11/16 | 24500 |
| 61 | 7/16 | 1/2 | 9/16 | 9/16 | 11/16 | 3/4 | 7/16 | 1/2 | 9/16 | 5/8 | 1½ | 2 | 4 | 5 | 7-10 | 36 | 70 | 28800 | 80⅛ | 4-4⅝ | 20-5 | 24-6½ | 24-9¾ | 9/16 | 11/16 | 3/4 | 31000 |
| 67 | 1/2 | 9/16 | 5/8 | 5/8 | 11/16 | 13/16 | 7/16 | 9/16 | 5/8 | 5/8 | 1½ | 2 | 4 | 5 | 8-4 | 39 | 70 | 35000 | 86¼ | 4-7⅝ | 20-5 | 25-0 | 25-3¼ | 5/8 | 11/16 | 13/16 | 38000 |
| 74 | 9/16 | 5/8 | 11/16 | 5/8 | 3/4 | 7/8 | 7/16 | 9/16 | 5/8 | 5/8 | 1½ | 2½ | 4½ | 6 | 8-10 | 42 | 80 | 40000 | 92¼ | 4-10⅝ | 20-8 | 25-3 | 25-6½ | 5/8 | 13/16 | 7/8 | 43200 |
| 80 | 9/16 | 11/16 | 3/4 | 11/16 | 13/16 | 15/16 | 1/2 | 9/16 | 5/8 | 5/8 | 2 | 2½ | 4½ | 7 | 9-4 | 45 | 80 | 45000 | 98⅜ | 5-1⅝ | 20-8 | 25-11½ | 26-0½ | 11/16 | 13/16 | 15/16 | 48600 |
| 86 | 5/8 | 11/16 | 13/16 | 3/4 | 7/8 | 1 | 1/2 | 9/16 | 5/8 | 5/8 | 2 | 2½ | 5 | 8 | 9-11 | 48 | 80 | 50000 | 104½ | 5-4⅝ | 21-2 | 26-11½ | 27-0½ | 3/4 | 7/8 | 1 | 54000 |
| 92 | 5/8 | 3/4 | 7/8 | 3/4 | 7/8 | 1 | 1/2 | 9/16 | 5/8 | 5/8 | 2 | 2½ | 5 | 8 | 10-5 | 50 | 100 | 55000 | 110½ | 5-7⅛ | 21-2 | 26-11½ | 27-0½ | 3/4 | 7/8 | 1 | 59500 |
| 96 | 11/16 | 13/16 | 7/8 | 13/16 | 15/16 | 1 1/16 | 1/2 | 9/16 | 5/8 | 5/8 | 2 | 2½ | 2-4's | 8 | 10-9 | 52 | 100 | 60000 | 114⅛ | 5-9⅝ | 21-2 | 26-11½ | 27-0½ | 13/16 | 15/16 | 1 1/16 | 65000 |

* Tensile strength of plate 58,000 pounds. (Factor of safety of 5 used.)
† For other dimensions of plain upright boilers, see corresponding size of Manning boiler
‡ This dimension same as outside diameter of furnace of corresponding Manning boiler.



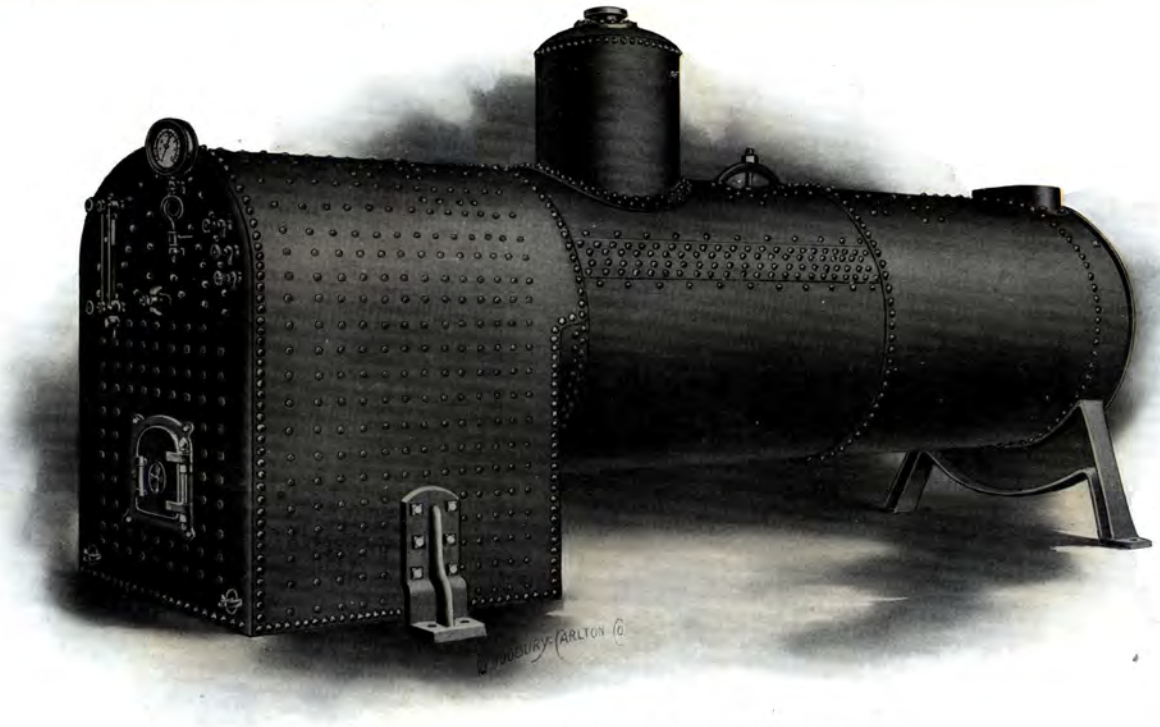
# Small Vertical Boilers

**Showing different designs of Bonnets and Bases, also general construction.**

## GENERAL DIMENSIONS OF SMALL VERTICAL BOILERS.

| Rating | | Shell | | | Furnace | | Tubes, 2 in. diam. | | Thickness of material | | | Base | | Bonnet | | Hgt. of boiler | Stack | | Weight | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Horse power | Heating surface | Diameter | Height | Width of water leg ring | Diameter | Height | Number | Length | Shell | Furnace | Heads | Diam. at bottom | Height | Height | Smoke opening | Bottom of base to top of bonnet | Diameter required | Height required | Bare boiler | Boiler with fittings |
| | Sq. ft. | In | Ft.In | In. | In. | In. | | Ft.In. | In. | In. | In. | In. | In. | In. | In. | Ft. In. | In. | Ft. | Lbs. | Lbs. |
| 3.0 | 37.45 | 21 | 5-0 | 2 | 16 | 24 | 20 | 3-0 | ¼ | ¼ | 5/16 | 31 | 12 | 10 | 5 x 11 | 6-10 | 9 | 20 | 750 | 1100 |
| 5.0 | 63.62 | 24 | 5-6 | 2 | 19 | 24 | 32 | 3-6 | ¼ | ¼ | 5/16 | 34 | 12 | 11 | 6 x 14 | 7-5 | 10 | 20 | 950 | 1400 |
| 6.3 | 79.37 | 27 | 5-6 | 2 | 22 | 24 | 40 | 3-6 | ¼ | ¼ | 5/16 | 37 | 14 | 12 | 7 x 15 | 7-8 | 10 | 25 | 1175 | 1625 |
| 7.2 | 91.06 | 30 | 5-6 | 2 | 25 | 24 | 46 | 3-6 | ¼ | ¼ | 5/16 | 40 | 14 | 13 | 8 x 15 | 7-9 | 11 | 25 | 1400 | 1950 |
| 8.1 | 101.66 | 30 | 6-0 | 2 | 25 | 24 | 46 | 4-0 | ¼ | ¼ | 5/16 | 40 | 14 | 13 | 8 x 15 | 8-3 | 12 | 25 | 1500 | 2050 |
| 10.1 | 127.25 | 32 | 6-6 | 2 | 27 | 24 | 52 | 4-6 | ¼ | ¼ | 5/16 | 42 | 14 | 14 | 8 x 17 | 8-10 | 13 | 30 | 1650 | 2300 |
| 12.0 | 150.09 | 34 | 7-0 | 2½ | 28½ | 24 | 56 | 5-0 | ¼ | ¼ | 5/16 | 44 | 14 | 15 | 9 x 16 | 9-5 | 14 | 30 | 1875 | 2575 |
| 15.2 | 190.78 | 36 | 7-6 | 2½ | 30½ | 24 | 66 | 5-6 | ¼ | ¼ | 5/16 | 46 | 14 | 15 | 10 x 17 | 9-11 | 14 | 35 | 2250 | 3000 |
| 18.3 | 229.23 | 40 | 8-0 | 2½ | 34½ | 30 | 78 | 5-6 | 5/16 | 5/16 | 5/16 | 50 | 14 | 15 | 10 x 20 | 10-5 | 14 | 40 | 2750 | 3700 |
| 20.8 | 260.73 | 42 | 7-8 | 2½ | 36½ | 30 | 98 | 5-0 | 5/16 | 5/16 | 5/16 | 52 | 14 | 16 | 11 x 23 | 10-0 | 14 | 40 | 3200 | 4200 |
| 25.1 | 314.00 | 44 | 8-6 | 2½ | 38½ | 30 | 100 | 6-0 | 5/16 | 5/16 | 5/16 | 54 | 14 | 17 | 12 x 22 | 11-1 | 16 | 40 | 3700 | 4750 |
| 30.0 | 375.27 | 48 | 8-6 | 2½ | 42½ | 30 | 120 | 6-0 | 5/16 | 5/16 | 5/16 | 58 | 14 | 18 | 13 x 24 | 11-2 | 18 | 40 | 4200 | 5300 |
| 35.4 | 442.91 | 48 | 8-6 | 2½ | 42½ | 30 | 144 | 6-0 | 5/16 | 5/16 | 5/16 | 58 | 14 | 19 | 14 x 27 | 11-3 | 19 | 40 | 4450 | 5650 |
| 40.0 | 501.16 | 54 | 9-0 | 2½ | 48⅝ | 36 | 160 | 6-0 | 5/16 | 5/16 | 7/16 | 64 | 14 | 20 | 15 x 28 | 11-10 | 19 | 45 | 5200 | 6400 |
| 45.6 | 570.13 | 54 | 9-6 | 2½ | 48⅝ | 36 | 170 | 6-6 | 5/16 | 5/16 | 7/16 | 64 | 14 | 21 | 16 x 28 | 12-5 | 20 | 45 | 5500 | 6700 |
| 50.0 | 625.18 | 54 | 9-6 | 2½ | 48⅝ | 36 | 188 | 6-6 | 5/16 | 5/16 | 7/16 | 64 | 14 | 22 | 17 x 29 | 12-6 | 21 | 50 | 5800 | 7000 |
| 60.4 | 755.56 | 60 | 9-6 | 2½ | 54⅛ | 36 | 228 | 6-6 | 5/16 | 5/16 | ½ | 70 | 16 | 23 | 18 x 33 | 12-9 | 22 | 50 | 7600 | 9000 |
| 73.3 | 917.44 | 60 | 11-0 | 2½ | 54⅛ | 36 | 228 | 8-0 | 5/16 | 5/16 | ½ | 70 | 16 | 23 | 18 x 33 | 14-3 | 24 | 50 | 8200 | 9600 |
| 82.9 | 1037.46 | 66 | 11-6 | 2½ | 59½ | 42 | 256 | 8-0 | 5/16 | 5/16 | ½ | 69 | 18 | 23 | 18 x 37 | 14-11 | 25 | 60 | 10800 | 11800 |
| 92.7 | 1158.75 | 66 | 12-6 | 2½ | 59½ | 42 | 256 | 9-0 | 5/16 | 5/16 | ½ | 69 | 18 | 23 | 18 x 37 | 15-11 | 26 | 60 | 11300 | 13300 |

*12½ square feet of heating surface per horse power



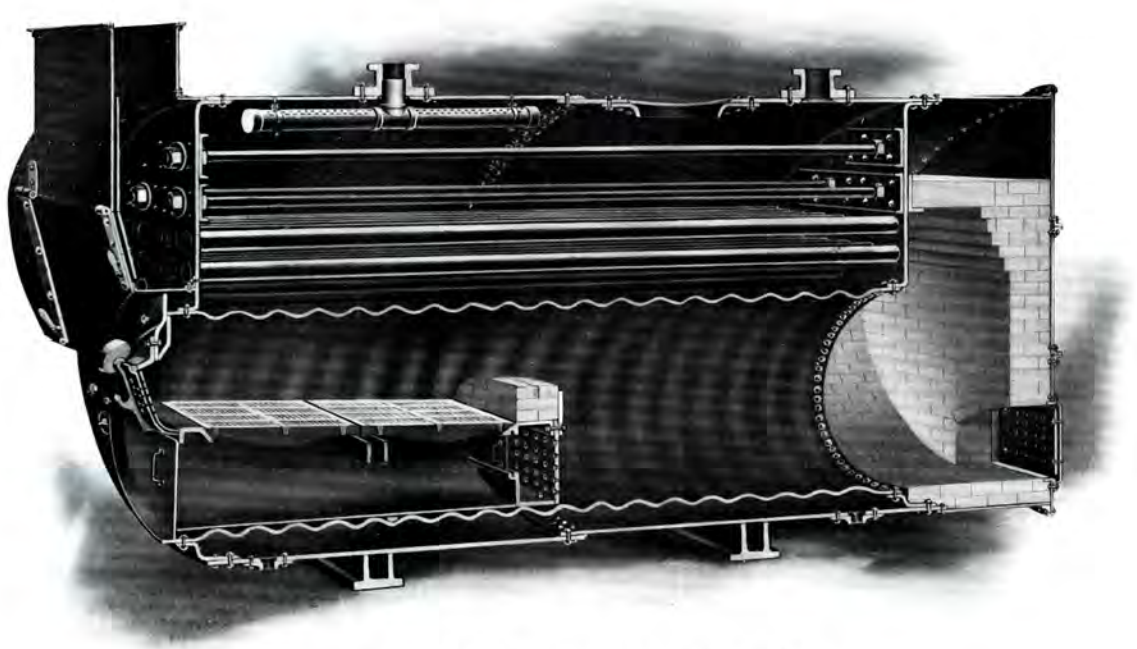
# Locomotive Boiler

**Showing Butt-Strap Joint, Steam Dome Double Riveted to Boiler, Stay Bolting for high pressure and general construction.**

## GENERAL DIMENSIONS OF LOCOMOTIVE BOILERS.

| Rating | | Size of boiler | | | Furnace | | | Tubes, 3″ dia. | | Thickness of material | | | Dome | | Stack | | Weights | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Horse power | Heating surface | Diam. of waist | Length of boiler | Height from bottom of water leg to top of shell | Length | Width | Height | Number | Length | Shell and front Plate | Front, sides and top of furnace | Tube sheets | Diameter | Height | Diam. required | Height required | Bare boiler | Boiler with fittings |
| | Sq. Ft. | In. | Ft. In. | Ft.In. | In. | In. | In. | | Ft. In. | In. | In. | In. | In. | In. | In. | Ft. | Lbs. | Lbs. |
| 20.8 | 208.3 | 36 | 14-0 | 4-0 | 48 | 30 | 32 | 28 | 8-0 | 5/16 | 5/16 | 9/32 | 20 | 18 | 14 | 40 | 5000 | 5700 |
| 25.5 | 255.6 | 40 | 14-0 | 4-5 | 48 | 34 | 39 | 34 | 8-0 | 5/16 | 5/16 | 9/32 | 24 | 24 | 16 | 40 | 6600 | 7600 |
| 30.9 | 309.25 | 42 | 14-10 | 4-8 | 50 | 36 | 40 | 40 | 8-6 | 5/16 | 5/16 | 9/32 | 24 | 24 | 18 | 40 | 7200 | 8200 |
| 35.5 | 355.21 | 44 | 15-6 | 4-10 | 50 | 38 | 44 | 44 | 9-0 | 5/16 | 5/16 | 9/32 | 24 | 24 | 19 | 40 | 7800 | 8825 |
| 41.9 | 419.45 | 44 | 17-6 | 4-10 | 50 | 38 | 44 | 44 | 11-0 | 5/16 | 5/16 | 9/32 | 24 | 24 | 19 | 45 | 8100 | 9125 |
| 51.5 | 515.35 | 48 | 18-0 | 5-7 | 54 | 42 | 48 | 54 | 11-0 | 5/16 | 5/16 | 9/32 | 24 | 24 | 21 | 50 | 9350 | 10550 |
| 62.2 | 622.92 | 54 | 19-6 | 5-11 | 60 | 48 | 50 | 60 | 12-0 | 5/16 | 5/16 | 9/32 | 30 | 30 | 22 | 50 | 11300 | 12700 |
| 72.7 | 727.72 | 56 | 20-6 | 6-0 | 60 | 50 | 52 | 66 | 13-0 | 3/8 | 5/16 | 7/16 | 30 | 30 | 24 | 50 | 13100 | 14650 |
| 82.8 | 828.76 | 58 | 20-9 | 6-5 | 60 | 52 | 54 | 76 | 13-0 | 3/8 | 5/16 | 7/16 | 30 | 30 | 25 | 60 | 14150 | 16000 |
| 91.9 | 919.10 | 60 | 21-6 | 6-6 | 60 | 54 | 54 | 82 | 13-6 | 3/8 | 5/16 | 7/16 | 30 | 30 | 26 | 60 | 15700 | 17600 |
| 103.3 | 1033.18 | 62 | 22-3 | 6-9 | 60 | 56 | 56 | 90 | 14-0 | 3/8 | 5/16 | 7/16 | 30 | 36 | 28 | 60 | 16750 | 18800 |
| 114.4 | 1144.94 | 66 | 21-9 | 7-2 | 60 | 60 | 56 | 104 | 13-6 | 7/16 | 3/8 | 1/2 | 30 | 36 | 30 | 60 | 17100 | 20000 |
| 125.8 | 1258.3 | 66 | 23-3 | 7-2 | 60 | 60 | 56 | 104 | 15-0 | 7/16 | 3/8 | 1/2 | 30 | 36 | 30 | 65 | 18200 | 21400 |
| 154.6 | 1546.49 | 72 | 23-3 | 7-8 | 66 | 66 | 62 | 128 | 15-0 | 7/16 | 3/8 | 1/2 | 36 | 36 | 34 | 70 | 20300 | 24600 |

* 10 square feet of heating surface per horse power.

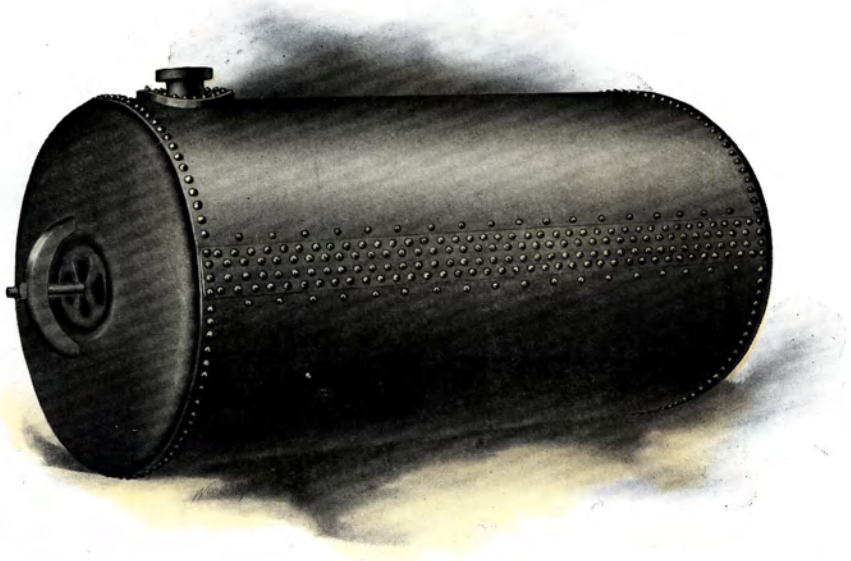


# Internal Furnace Boiler

Longitudinal section of internal furnace boiler, showing Morison suspension furnace complete with front and fire door, smoke flue connection, dry pipe and general construction. In designing the internal furnace boilers, an evaporation of 10 pounds of water per pound of coal, having 10% ash, and a consumption of 18 pounds of coal per square foot of grate per hour, have been used as a basis. With the above data a simple calculation shows that these boilers should produce 5 boiler horse power per square foot of grate.

**GENERAL DIMENSIONS OF INTERNAL FURNACE BOILERS**

| Rated horse power | 50 | 75 | 100 | 100 | 125 | 125 | 150 | 150 | 200 | 200 | 250 | 250 | 300 | 300 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Design of boiler | A | A | A | B | A | B | A | B | A | B | A | B | A | B |
| Grate surface in square feet | 12 | 15 | 20 | 20 | 25 | 25 | 30 | 30 | 40 | 40 | 50 | 50 | 60 | 60 |
| Heating surface in square feet | 423 | 527 | 733 | 797 | 905 | 1001 | 1071 | 1176 | 1423 | 1662 | 1780 | 2004 | 2157 | 2403 |
| Ratio of H. S. to G. S. | 35.2 to 1 | 35.2 to 1 | 36.6 to 1 | 39.8 to 1 | 36.2 to 1 | 40. to 1 | 35.7 to 1 | 39.2 to 1 | 35.6 to 1 | 41.5 to 1 | 35.6 to 1 | 40. to 1 | 35.9 to 1 | 40. to 1 |
| Diameter of tubes in inches | 3 | 3½ | 3½ | 4 | 3½ | 4 | 3½ | 4 | 3½ | 4 | 3½ | 4 | 3½ | 4 |
| Number of tubes | 48 | 42 | 56 | 40 | 70 | 52 | 80 | 62 | 108 | 84 | 137 | 104 | 161 | 127 |
| Length of tubes in feet and inches | 9-6 | 11-6 | 12-6 | 16-0 | 12-6 | 16-0 | 13-0 | 16-0 | 12-6 | 16-0 | 12-6 | 16-0 | 13-0 | 16-0 |
| Area through tubes in square feet | 2.02 | 2.44 | 3.25 | 3.04 | 4.06 | 3.95 | 4.64 | 4.71 | 6.26 | 6.38 | 7.95 | 7.91 | 9.34 | 9.65 |
| Ratio area through tubes to grate sur. | 1 to 5.94 | 1 to 6.15 | 1 to 6.15 | 1 to 6.57 | 1 to 6.15 | 1 to 6.33 | 1 to 6.46 | 1 to 6.37 | 1 to 6.39 | 1 to 6.27 | 1 to 6.29 | 1 to 6.32 | 1 to 6.42 | 1 to 6.22 |
| Inside diam. of boiler shell. Ft. in. | 6-3 | 6-6 | 7-0 | 6-9 | 7-6 | 7-3 | 8-0 | 7-9 | 9-6 | 9-4 | 10-6 | 10-0 | 11-6 | 10-9 |
| Inside diam. of corrugated fur. In. | 36 | 36 | 38 | 38 | 45 | 41 | 50 | 45 | 38 | 38 | 45 | 41 | 50 | 45 |
| Length of grate in feet and inches. | 4-0 | 5-0 | 6-4 | 6-4 | 6-8 | 7-4 | 7-3 | 8-0 | 6-4 | 6-4 | 6-8 | 7-4 | 7-3 | 8-0 |
| Depth combustion chamber. Ft.in. | 2-0 | 2-0 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 | 2-6 |



**High Pressure Tank**

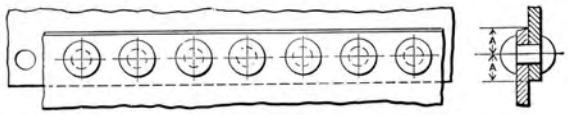
**Bleaching Kier**

# Riveted Joints

The following tables compiled from data furnished by the Hartford Steam Boiler Inspection and Insurance Co. on steel rivets and steel plates.

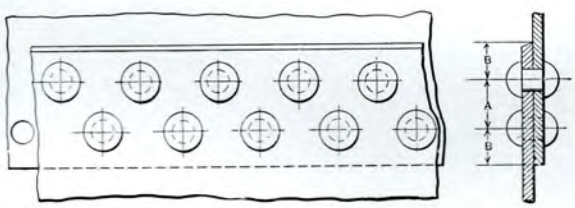
Rivets 42,000 lbs. single shear and 78,000 lbs. double shear.

Plates and straps 55,000 lbs. T. S.



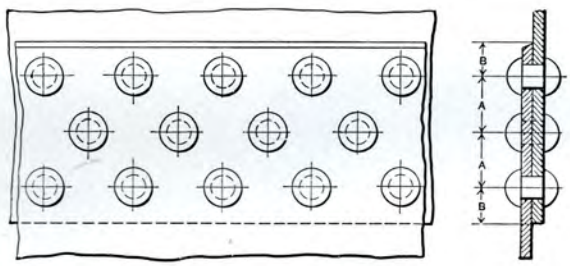
## Table of Dimensions of Single Riveted Lap Joints.

| Thickness of plate. In. | Diam. of rivet hole. In. | Efficiency % | Pitch of rivets. In. | A In. |
|---|---|---|---|---|
| 1/4 | 5/8 | 58.3 | 1 1/2 | 15/16 |
| 9/32 | 11/16 | 59.2 | 1 11/16 | 1 1/32 |
| 5/16 | 3/4 | 57.5 | 1 13/16 | 1 1/8 |
| 11/32 | 7/8 | 58.8 | 2 1/8 | 1 5/16 |
| 3/8 | 7/8 | 57.6 | 2 1/8 | 1 5/16 |
| 13/32 | 15/16 | 57.6 | 2 1/4 | 1 13/32 |
| 7/16 | 1 | 57.7 | 2 3/8 | 1 1/2 |
| 15/32 | 1 1/16 | 56.4 | 2 7/16 | 1 9/32 |
| 1/2 | 1 1/16 | 54.8 | 2 5/32 | 1 9/32 |



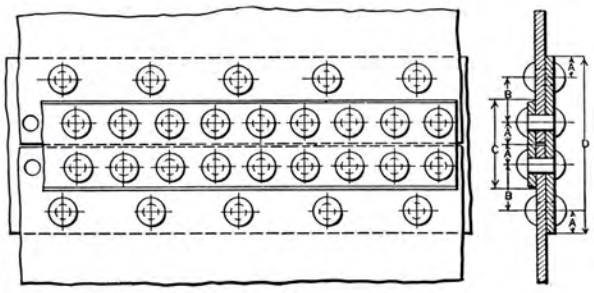
## Table of Dimensions of Double Riveted Lap Joints.

| Thickness of plate. In. | Diam. of rivet hole. In. | Efficiency % | Pitch of rivets. In | A In. | B In. |
|---|---|---|---|---|---|
| 1/4 | 5/8 | 74.3 | 2 7/16 | 1 1/2 | 15/16 |
| 9/32 | 5/8 | 74.3 | 2 7/16 | 1 1/2 | 15/16 |
| 5/16 | 11/16 | 72.5 | 2 1/2 | 1 9/16 | 1 1/32 |
| 11/32 | 11/16 | 72.5 | 2 1/2 | 1 9/16 | 1 1/32 |
| 3/8 | 13/16 | 71.7 | 2 5/8 | 1 3/4 | 1 7/32 |
| 13/32 | 13/16 | 71.7 | 2 5/8 | 1 3/4 | 1 7/32 |
| 7/16 | 15/16 | 71.1 | 3 1/4 | 2 | 1 13/32 |
| 15/32 | 15/16 | 71.1 | 3 1/4 | 2 | 1 13/32 |
| 1/2 | 1 | 70.3 | 3 3/8 | 2 1/16 | 1 1/2 |



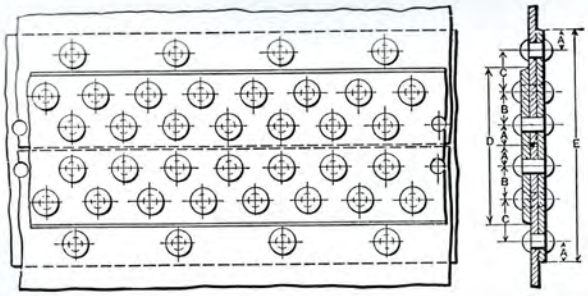
## Table of Dimensions of Treble Riveted Lap Joints.

| Thickness of plate In. | Diam. of rivet hole. In. | Efficiency % | Pitch of rivets. In. | A In. | B In. |
|---|---|---|---|---|---|
| 1/4 | 5/8 | 78.2 | 2 7/8 | 1 3/4 | 15/16 |
| 9/32 | 5/8 | 78.2 | 2 7/8 | 1 3/4 | 15/16 |
| 5/16 | 11/16 | 77.0 | 3 | 1 7/8 | 1 1/16 |
| 11/32 | 11/16 | 77.0 | 3 | 1 7/8 | 1 1/16 |
| 3/8 | 13/16 | 75.0 | 3 1/4 | 2 1/8 | 1 7/32 |
| 13/32 | 13/16 | 75.0 | 3 1/4 | 2 1/8 | 1 7/32 |
| 7/16 | 7/8 | 75.0 | 3 1/2 | 2 1/4 | 1 5/16 |
| 15/32 | 15/16 | 75.0 | 3 3/4 | 2 3/8 | 1 13/32 |
| 1/2 | 15/16 | 75.0 | 3 3/4 | 2 3/8 | 1 13/32 |



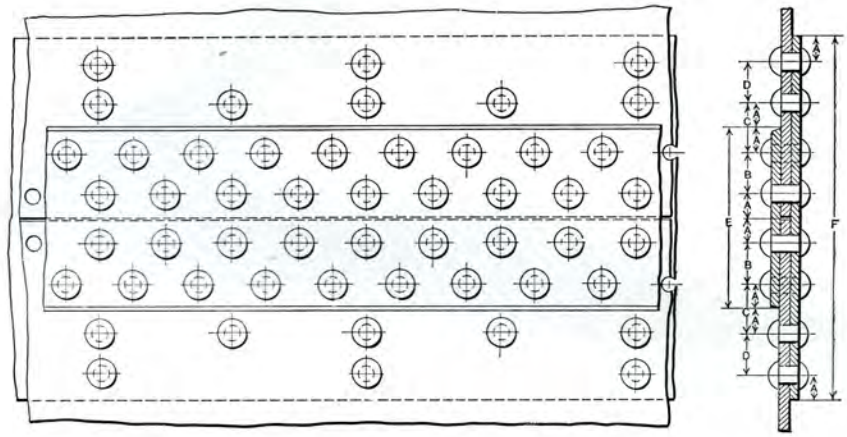
## Table of Dimensions of Double Riveted Butt Joints

| Thickness of plate. In. | Diam. of rivet hole. In. | Efficiency. % | Long pitch. In. | Short pitch. In. | A In. | B In. | C In. | D In. | Thickness of straps. In. |
|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{4}$ | $\frac{11}{16}$ | 82.8 | 4 | 2 | $1\frac{1}{32}$ | $2\frac{1}{16}$ | $4\frac{1}{8}$ | $8\frac{1}{4}$ | $\frac{7}{32}$ |
| $\frac{9}{32}$ | $\frac{11}{16}$ | 83.3 | $4\frac{1}{8}$ | $2\frac{1}{16}$ | $1\frac{1}{32}$ | $2\frac{1}{16}$ | $4\frac{1}{8}$ | $8\frac{1}{4}$ | $\frac{7}{32}$ |
| $\frac{5}{16}$ | $\frac{3}{4}$ | 83.3 | $4\frac{1}{2}$ | $2\frac{1}{4}$ | $1\frac{1}{8}$ | $2\frac{1}{4}$ | $4\frac{1}{2}$ | 9 | $\frac{1}{4}$ |
| $\frac{11}{32}$ | $\frac{3}{4}$ | 83.3 | $4\frac{1}{2}$ | $2\frac{1}{4}$ | $1\frac{1}{8}$ | $2\frac{1}{4}$ | $4\frac{1}{2}$ | 9 | $\frac{9}{32}$ |
| $\frac{3}{8}$ | $\frac{13}{16}$ | 83.0 | $4\frac{25}{32}$ | $2\frac{25}{64}$ | $1\frac{7}{32}$ | $2\frac{7}{16}$ | $4\frac{7}{8}$ | $9\frac{3}{4}$ | $\frac{5}{16}$ |
| $\frac{7}{16}$ | $\frac{7}{8}$ | 82.5 | 5 | $2\frac{1}{2}$ | $1\frac{5}{16}$ | $2\frac{5}{8}$ | $5\frac{1}{4}$ | $10\frac{1}{2}$ | $\frac{3}{8}$ |
| $\frac{1}{2}$ | $\frac{15}{16}$ | 81.7 | $5\frac{1}{8}$ | $2\frac{9}{16}$ | $1\frac{13}{32}$ | $2\frac{13}{16}$ | $5\frac{1}{8}$ | $11\frac{1}{4}$ | $\frac{7}{16}$ |



## Table of Dimensions of Treble Riveted Butt Joints

| Thickness of plate. In. | Diam. of rivet hole. In. | Efficiency % | Long pitch. In. | Short pitch. In. | A In. | B In. | C In. | D In. | E In. | Thickness of straps. In. |
|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{4}$ | $\frac{9}{16}$ | 87.5 | $4\frac{1}{2}$ | $2\frac{1}{4}$ | $\frac{27}{32}$ | $1\frac{3}{8}$ | $1\frac{11}{16}$ | $6\frac{1}{8}$ | $9\frac{1}{2}$ | $\frac{3}{16}$ |
| $\frac{5}{16}$ | $\frac{3}{4}$ | 88.0 | $6\frac{1}{4}$ | $3\frac{1}{8}$ | $1\frac{1}{8}$ | $1\frac{7}{8}$ | $2\frac{1}{4}$ | $8\frac{1}{4}$ | $12\frac{3}{4}$ | $\frac{1}{4}$ |
| $\frac{11}{32}$ | $\frac{3}{4}$ | 88.0 | $6\frac{1}{4}$ | $3\frac{1}{8}$ | $1\frac{1}{8}$ | $1\frac{7}{8}$ | $2\frac{1}{4}$ | $8\frac{1}{4}$ | $12\frac{3}{4}$ | $\frac{1}{4}$ |
| $\frac{3}{8}$ | $\frac{13}{16}$ | 87.5 | $6\frac{1}{2}$ | $3\frac{1}{4}$ | $1\frac{7}{32}$ | 2 | $2\frac{7}{16}$ | $8\frac{7}{8}$ | $13\frac{3}{4}$ | $\frac{5}{16}$ |
| $\frac{13}{32}$ | $\frac{13}{16}$ | 87.5 | $6\frac{1}{2}$ | $3\frac{1}{4}$ | $1\frac{7}{32}$ | 2 | $2\frac{7}{16}$ | $8\frac{7}{8}$ | $13\frac{3}{4}$ | $\frac{5}{16}$ |
| $\frac{7}{16}$ | $\frac{15}{16}$ | 86.1 | $6\frac{3}{4}$ | $3\frac{3}{8}$ | $1\frac{13}{32}$ | $2\frac{1}{32}$ | $2\frac{13}{16}$ | $9\frac{11}{16}$ | $15\frac{5}{16}$ | $\frac{3}{8}$ |
| $\frac{15}{32}$ | $\frac{15}{16}$ | 86.6 | 7 | $3\frac{1}{2}$ | $1\frac{13}{32}$ | $2\frac{1}{8}$ | $2\frac{13}{16}$ | $9\frac{7}{8}$ | $15\frac{1}{2}$ | $\frac{3}{8}$ |
| $\frac{1}{2}$ | $1\frac{1}{16}$ | 85.84 | $7\frac{1}{2}$ | $3\frac{3}{4}$ | $1\frac{19}{32}$ | $2\frac{1}{4}$ | $3\frac{3}{16}$ | $10\frac{7}{8}$ | $17\frac{1}{4}$ | $\frac{3}{8}$ |
| $\frac{17}{32}$ | $1\frac{1}{16}$ | 85.83 | $7\frac{1}{2}$ | $3\frac{3}{4}$ | $1\frac{19}{32}$ | $2\frac{1}{4}$ | $3\frac{3}{16}$ | $10\frac{7}{8}$ | $17\frac{1}{4}$ | $\frac{13}{32}$ |
| $\frac{9}{16}$ | $1\frac{1}{16}$ | 85.95 | $7\frac{9}{16}$ | $3\frac{25}{32}$ | $1\frac{19}{32}$ | $2\frac{9}{32}$ | $3\frac{3}{16}$ | $10\frac{15}{16}$ | $17\frac{5}{16}$ | $\frac{7}{16}$ |
| $\frac{5}{8}$ | $1\frac{1}{16}$ | 86.3 | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{19}{32}$ | $2\frac{5}{16}$ | $3\frac{3}{16}$ | 11 | $17\frac{3}{8}$ | $\frac{15}{32}$ |
| $\frac{11}{16}$ | $1\frac{3}{16}$ | 84.7 | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{25}{32}$ | $2\frac{5}{16}$ | $3\frac{9}{16}$ | $11\frac{3}{4}$ | $18\frac{7}{8}$ | $\frac{17}{32}$ |
| $\frac{3}{4}$ | $1\frac{3}{16}$ | 84.1 | $7\frac{7}{8}$ | $3\frac{15}{16}$ | $1\frac{25}{32}$ | $2\frac{3}{8}$ | $3\frac{9}{16}$ | $11\frac{7}{8}$ | 19 | $\frac{9}{16}$ |




## Table of Dimensions of Quadruple Riveted Butt Joints

| Thickness of plate. In. | Diam. of rivet hole. In. | Efficiency % | Long pitch. In. | Middle pitch. In. | Short pitch. In. | A In. | B In. | C In. | D In. | E In. | F In. | Thickness of straps. In. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{4}$ | $\frac{9}{16}$ | 94.9 | 11 | $5\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{27}{32}$ | $1\frac{11}{16}$ | $1\frac{11}{16}$ | $1\frac{5}{8}$ | $6\frac{3}{4}$ | $13\frac{3}{8}$ | $\frac{3}{16}$ |
| $\frac{9}{32}$ | $\frac{5}{8}$ | 94.8 | 12 | 6 | 3 | $\frac{15}{16}$ | $1\frac{13}{16}$ | $1\frac{7}{8}$ | $1\frac{3}{4}$ | $7\frac{5}{8}$ | $14\frac{5}{8}$ | $\frac{3}{16}$ |
| $\frac{5}{16}$ | $\frac{3}{4}$ | 94.6 | 14 | 7 | $3\frac{1}{2}$ | $1\frac{1}{8}$ | $2\frac{1}{8}$ | $2\frac{1}{4}$ | 2 | $8\frac{3}{4}$ | $17\frac{1}{4}$ | $\frac{1}{4}$ |
| $\frac{11}{32}$ | $\frac{3}{4}$ | 94.6 | 14 | 7 | $3\frac{1}{2}$ | $1\frac{1}{8}$ | $2\frac{1}{8}$ | $2\frac{1}{4}$ | 2 | $8\frac{3}{4}$ | $17\frac{1}{4}$ | $\frac{1}{4}$ |
| $\frac{3}{8}$ | $\frac{3}{4}$ | 94.6 | 14 | 7 | $3\frac{1}{2}$ | $1\frac{1}{8}$ | $2\frac{1}{8}$ | $2\frac{1}{4}$ | 2 | $8\frac{3}{4}$ | $17\frac{1}{4}$ | $\frac{5}{16}$ |
| $\frac{13}{32}$ | $\frac{7}{8}$ | 94.0 | $14\frac{5}{8}$ | $7\frac{5}{16}$ | $3\frac{21}{32}$ | $1\frac{5}{16}$ | $2\frac{3}{16}$ | $2\frac{3}{8}$ | $2\frac{1}{4}$ | $9\frac{1}{8}$ | $19\frac{3}{8}$ | $\frac{5}{16}$ |
| $\frac{7}{16}$ | $\frac{7}{8}$ | 94.1 | 15 | $7\frac{1}{2}$ | $3\frac{3}{4}$ | $1\frac{5}{16}$ | $2\frac{1}{4}$ | $2\frac{5}{8}$ | $2\frac{1}{4}$ | $9\frac{1}{4}$ | $19\frac{1}{2}$ | $\frac{3}{8}$ |
| $\frac{15}{32}$ | $\frac{15}{16}$ | 94.0 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{13}{32}$ | $2\frac{11}{32}$ | $2\frac{13}{16}$ | $2\frac{3}{8}$ | $10\frac{5}{16}$ | $20\frac{11}{16}$ | $\frac{3}{8}$ |
| $\frac{1}{2}$ | $\frac{15}{16}$ | 94.0 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{13}{32}$ | $2\frac{11}{32}$ | $2\frac{13}{16}$ | $2\frac{3}{8}$ | $10\frac{5}{16}$ | $20\frac{11}{16}$ | $\frac{3}{8}$ |
| $\frac{17}{32}$ | $\frac{15}{16}$ | 94.0 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{13}{32}$ | $2\frac{11}{32}$ | $2\frac{13}{16}$ | $2\frac{3}{8}$ | $10\frac{5}{16}$ | $20\frac{11}{16}$ | $\frac{13}{32}$ |
| $\frac{9}{16}$ | $\frac{15}{16}$ | 94.0 | $15\frac{11}{16}$ | $7\frac{27}{32}$ | $3\frac{59}{64}$ | $1\frac{13}{32}$ | $2\frac{11}{32}$ | $2\frac{13}{16}$ | $2\frac{3}{8}$ | $10\frac{5}{16}$ | $20\frac{11}{16}$ | $\frac{7}{16}$ |
| $\frac{19}{32}$ | $1\frac{1}{16}$ | 93.6 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{19}{32}$ | $2\frac{5}{16}$ | $3\frac{3}{16}$ | $2\frac{5}{8}$ | 11 | $22\frac{5}{8}$ | $\frac{7}{16}$ |
| $\frac{5}{8}$ | $1\frac{1}{16}$ | 93.1 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{19}{32}$ | $2\frac{5}{16}$ | $3\frac{3}{16}$ | $2\frac{5}{8}$ | 11 | $22\frac{5}{8}$ | $\frac{15}{32}$ |
| $\frac{21}{32}$ | $1\frac{1}{16}$ | 92.5 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{19}{32}$ | $2\frac{5}{16}$ | $3\frac{3}{16}$ | $2\frac{5}{8}$ | 11 | $22\frac{5}{8}$ | $\frac{1}{2}$ |
| $\frac{11}{16}$ | $1\frac{3}{16}$ | 92.4 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{25}{32}$ | $2\frac{11}{32}$ | $3\frac{0}{16}$ | $2\frac{7}{8}$ | $11\frac{3}{16}$ | $24\frac{1}{16}$ | $\frac{17}{32}$ |
| $\frac{23}{32}$ | $1\frac{3}{16}$ | 92.4 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{25}{32}$ | $2\frac{5}{16}$ | $3\frac{7}{16}$ | $2\frac{7}{8}$ | $11\frac{3}{4}$ | $24\frac{5}{8}$ | $\frac{17}{32}$ |
| $\frac{3}{4}$ | $1\frac{3}{16}$ | 91.1 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{25}{32}$ | $2\frac{5}{16}$ | $3\frac{9}{16}$ | $2\frac{7}{8}$ | $11\frac{3}{4}$ | $24\frac{5}{8}$ | $\frac{9}{16}$ |
| $\frac{25}{32}$ | $1\frac{3}{16}$ | 90.3 | $15\frac{1}{2}$ | $7\frac{3}{4}$ | $3\frac{7}{8}$ | $1\frac{25}{32}$ | $2\frac{5}{16}$ | $3\frac{9}{16}$ | $2\frac{7}{8}$ | $11\frac{3}{4}$ | $24\frac{5}{8}$ | $\frac{19}{32}$ |
| $\frac{13}{16}$ | $1\frac{5}{16}$ | 90.8 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{31}{32}$ | $2\frac{11}{32}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{9}{16}$ | $26\frac{1}{16}$ | $\frac{5}{8}$ |
| $\frac{27}{32}$ | $1\frac{5}{16}$ | 89.9 | $15\frac{5}{8}$ | $7\frac{13}{16}$ | $3\frac{29}{32}$ | $1\frac{31}{32}$ | $2\frac{11}{32}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{9}{16}$ | $26\frac{1}{16}$ | $\frac{5}{8}$ |
| $\frac{7}{8}$ | $1\frac{5}{16}$ | 89.1 | $15\frac{3}{4}$ | $7\frac{7}{8}$ | $3\frac{15}{16}$ | $1\frac{31}{32}$ | $2\frac{3}{8}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{5}{8}$ | $26\frac{3}{4}$ | $\frac{21}{32}$ |
| $\frac{29}{32}$ | $1\frac{5}{16}$ | 88.3 | $15\frac{3}{4}$ | $7\frac{7}{8}$ | $3\frac{15}{16}$ | $1\frac{31}{32}$ | $2\frac{3}{8}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{5}{8}$ | $26\frac{3}{4}$ | $\frac{11}{16}$ |
| $\frac{15}{16}$ | $1\frac{5}{16}$ | 87.8 | 16 | 8 | 4 | $1\frac{31}{32}$ | $2\frac{13}{32}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{11}{16}$ | $26\frac{13}{16}$ | $\frac{23}{32}$ |
| $\frac{31}{32}$ | $1\frac{5}{16}$ | 87.1 | 16 | 8 | 4 | $1\frac{31}{32}$ | $2\frac{13}{32}$ | $3\frac{15}{16}$ | $3\frac{1}{8}$ | $12\frac{11}{16}$ | $26\frac{13}{16}$ | $\frac{3}{4}$ |
| 1 | $1\frac{7}{16}$ | 87.3 | 16 | 8 | 4 | $2\frac{5}{32}$ | $2\frac{13}{32}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{7}{16}$ | $28\frac{13}{16}$ | $\frac{3}{4}$ |
| $1\frac{1}{32}$ | $1\frac{7}{16}$ | 86.6 | 16 | 8 | 4 | $2\frac{5}{32}$ | $2\frac{13}{32}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{7}{16}$ | $28\frac{13}{16}$ | $\frac{25}{32}$ |
| $1\frac{1}{16}$ | $1\frac{7}{16}$ | 86.3 | $16\frac{1}{2}$ | $8\frac{1}{4}$ | $4\frac{1}{8}$ | $2\frac{5}{32}$ | $2\frac{5}{32}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{9}{16}$ | $28\frac{15}{16}$ | $\frac{25}{32}$ |
| $1\frac{3}{32}$ | $1\frac{7}{16}$ | 85.9 | $16\frac{3}{4}$ | $8\frac{3}{8}$ | $4\frac{3}{16}$ | $2\frac{5}{32}$ | $2\frac{1}{2}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{5}{8}$ | 29 | $\frac{13}{16}$ |
| $1\frac{1}{8}$ | $1\frac{7}{16}$ | 85.4 | $16\frac{3}{4}$ | $8\frac{3}{8}$ | $4\frac{3}{16}$ | $2\frac{5}{32}$ | $2\frac{1}{2}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{5}{8}$ | 29 | $\frac{27}{32}$ |
| $1\frac{5}{32}$ | $1\frac{7}{16}$ | 84.8 | $16\frac{3}{4}$ | $8\frac{3}{8}$ | $4\frac{3}{16}$ | $2\frac{5}{32}$ | $2\frac{1}{2}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{5}{8}$ | 29 | $\frac{7}{8}$ |
| $1\frac{3}{16}$ | $1\frac{7}{16}$ | 84.5 | 17 | $8\frac{1}{2}$ | $4\frac{1}{4}$ | $2\frac{5}{32}$ | $2\frac{9}{16}$ | $4\frac{5}{16}$ | $3\frac{3}{8}$ | $13\frac{3}{4}$ | $29\frac{1}{8}$ | $\frac{7}{8}$ |
| $1\frac{7}{32}$ | $1\frac{9}{16}$ | 84.4 | 17 | $8\frac{1}{2}$ | $4\frac{1}{4}$ | $2\frac{11}{32}$ | $2\frac{9}{16}$ | $4\frac{11}{16}$ | $3\frac{5}{8}$ | $14\frac{1}{2}$ | $31\frac{1}{8}$ | $\frac{29}{32}$ |
| $1\frac{1}{4}$ | $1\frac{9}{16}$ | 84.1 | $17\frac{1}{8}$ | $8\frac{9}{16}$ | $4\frac{9}{32}$ | $2\frac{11}{32}$ | $2\frac{9}{16}$ | $4\frac{11}{16}$ | $3\frac{5}{8}$ | $14\frac{1}{2}$ | $31\frac{1}{8}$ | $\frac{15}{16}$ |

# Horse Power of Boilers

CORRECTLY speaking, there is no such term as horse power applied to steam boilers, but as steam boilers must have some unit of rating, the same measure applied to steam engines has come to be universally applied to them. This standard, as fixed by Watt, was one cubic foot of water evaporated per hour, from 212°, for each horse power. This was at that time the requirement of the best engines in use.

To obviate the confusion resulting from an indefinite meaning of the term boiler horse power, the judges in charge of boiler trials at the Centennial Exposition, in 1876, ascertained that a good engine of the prevailing type at that time required about 30 pounds of steam per hour per horse power developed. In order to establish a relation between engine and bolier power, they recommended that an evaporation of 30 pounds of water per hour from an initial feed temperature of 100°F. to steam at 70 pounds gauge pressure, be considered as one boiler horse power. This standard has been generally accepted by American engineers, and is equivalent to an evaporation of 34½ pounds of water per hour from and at 212°F. Expressed in this form, it has been endorsed by the American Society of Mechanical Engineers. It is, therefore, purely a measure of evaporation.

An ordinary engine, medium size, of the four-valve automatic cut-off type, running non-condensing at 80 pounds pressure, uses about 27 pounds of steam per horse power per hour, and 21 pounds when running with condenser. An unjacketed compound condensing engine running at a pressure of 125 pounds uses about 15 pounds of steam per indicated horse power per hour. In a number of cases, where the most approved compound engines have been used, running at high pressure, a horse power has been produced from 12½ pounds of steam. As the best types of horizontal tubular and Manning upright boilers will evaporate considerably over 10 pounds of water per pound of coal, it is possible to produce a horse power per hour on this type of engine from 1.25 pounds of coal.

A 100 horse power boiler, working at its full capacity, should furnish a sufficient quantity of steam to develop in the three most common types of engines, the following quantities of power:

| | |
|---|---|
| Plain non-condensing engine . . . . . | 111 horse power. |
| Plain condensing engine . . . . . | 143 horse power. |
| Compound condensing engine (ordinary conditions) | 200 horse power. |
| Compound condensing engine consuming 12½ pounds of steam per indicated horse power per hour | 240 horse power. |

It is true that some types of gas and oil engines can produce, when first installed, a horse power at less cost than the steam engine, but the cost of maintenance, uncertainty of regulation, unreliability and rapid deterioration, reduce their efficiency to such an extent, that in eight or ten years a good engine is far superior.

In the early days of power plants, when steam boilers were made in small units and for low pressure, it was customary in computing the horse power of boilers to call 15 square feet of heating surface a horse power, and all boilers were rated accordingly.

As time passed, it was found by increasing the grate surface and burning more coal per square foot of grate per hour, that a horse power could be obtained from 10 square feet or less of heating surface, and a number of water tube boilers were sold on a basis of 7 or 8 square feet, and a few batteries even on 6 square feet of heating surface per horse power. Complete tests were made on these boilers and it was found that their efficiency had fallen off tremendously, and the temperature of the flue gases showed the grate surface altogether too large for the heating surface.

About ten years ago, a number of the leading engineers in this country found that in any well designed boiler, a horse power could be obtained on 10 square feet of heating surface with excellent economy, and since that time, 10 square feet has been the standard rating with most types of boilers, although one hears, even to-day, among the inexperienced that 10 square feet is all right when applied to water tube boilers, but that the horizontal tubular boilers should have the old rating of 15 square feet. The true facts as recognized at the present time are that the horizontal tubular boiler correctly designed, with a grate surface not less than $\frac{1}{30}$ the heating surface, and burning 17 pounds of good bituminous coal per hour, can easily produce a horse power on 10 square feet of heating surface and is more economical than a water tube boiler, for the simple reason that it is designed on more correct principles, and the heating surface is more efficient.

In a number of cases horizontal tubular boilers are replaced by other types of boilers, with the guarantee that the new boilers will be an improvement. Let us see what this statement means. The old boilers were built without any regard to the ratio of heating and steam space, and equipped with grates unable to burn more than 10 or 12 pounds of coal per square foot per hour, and the grate surfaces were altogether too small to furnish the steam desired. The smoke flue and chimney were of insufficient size to furnish a suitable draught, and the old brick setting full of cracks, which seriously reduced the efficiency of the boilers.

The new boilers are equipped with excellent stationary or shaking grates of suitable size, with ample air space, and a new chimney and smoke flue are installed to give the proper draught to burn at least 17 pounds of coal per square foot of grate per hour. The new boilers are then tested and the results compared with the old boilers. Is this a fair test?

At the present time, on account of the rapid development of water power privileges, it is interesting to compare the power so produced with the cost of power produced by steam. To make a fair comparison, it is only necessary to add to the cost of water power, the additional cost to furnish steam for heating and other purposes over and above the cost of doing this from a large steam power plant. We find this amount under ordinary conditions is equivalent to $5 per horse power per year. The cost of steam depends upon the cost of fuel and size and economy of steam plant. In the seaboard cities, the cost per horse power, in a first-class power plant of medium size, varies from $13 to $17 per year, while in the inland cities, $20 should be the maximum figure. In small plants (150 horse power), the cost should not exceed by $5 the above figures.

Thus, it is clearly shown that unless a water power company can supply power in seaboard cities at less than $15 per horse power per year, and in inland cities at less than $20, the proposition should not be considered by large steam users.

# TABLE OF PROPERTIES OF SATURATED STEAM

**Partly from C. H. Peabody's Tables.**

| Pressure in lbs. per square inch above vacuum | Temp. in degrees, Fahrenheit | Total heat in heat units from water at 32° | Heat in liquid from 32° in units | Heat of vaporization, or latent heat in ht. units | Density or weight of cu. ft. in pounds | Volume of one pound in cubic feet | Factor of equivalent evap. at 212° | Total pressure above vacuum |
|---|---|---|---|---|---|---|---|---|
| 1 | 101.99 | 1113.1 | 70.0 | 1043.0 | 0.00299 | 334.5 | .9661 | 1 |
| 2 | 126.27 | 1120.5 | 94.4 | 1026.1 | 0.00576 | 173.6 | .9738 | 2 |
| 3 | 141.62 | 1125.1 | 109.8 | 1015.3 | 0.00844 | 118.5 | .9786 | 3 |
| 4 | 153.09 | 1128.6 | 121.4 | 1007.2 | 0.01107 | 90.33 | .9822 | 4 |
| 5 | 162.34 | 1131.5 | 130.7 | 1000.8 | 0.01366 | 73.21 | .9852 | 5 |
| 6 | 170.14 | 1133.8 | 138.6 | 995.2 | 0.01622 | 61.65 | .9876 | 6 |
| 7 | 176.90 | 1135.9 | 145.4 | 990.5 | 0.01874 | 53.39 | .9897 | 7 |
| 8 | 182.92 | 1137.7 | 151.5 | 986.2 | 0.02125 | 47.06 | .9916 | 8 |
| 9 | 188.33 | 1139.4 | 156.9 | 982.5 | 0.02374 | 42.12 | .9934 | 9 |
| 10 | 193.25 | 1140.9 | 161.9 | 979.0 | 0.02621 | 38.15 | .9949 | 10 |
| 15 | 213.03 | 1146.9 | 181.8 | 965.1 | 0.03826 | 26.14 | 1.0003 | 15 |
| 20 | 227.95 | 1151.5 | 196.9 | 954.6 | 0.05023 | 19.91 | 1.0051 | 20 |
| 25 | 240.04 | 1155.1 | 209.1 | 946.0 | 0.06199 | 16.13 | 1.0099 | 25 |
| 30 | 250.27 | 1158.3 | 219.4 | 938.9 | 0.07360 | 13.59 | 1.0129 | 30 |
| 35 | 259.19 | 1161.0 | 228.4 | 932.6 | 0.08508 | 11.75 | 1.0157 | 35 |
| 40 | 267.13 | 1163.4 | 236.4 | 927.0 | 0.09644 | 10.37 | 1.0182 | 40 |
| 45 | 274.29 | 1165.6 | 243.6 | 922.0 | 0.1077 | 9.285 | 1.0205 | 45 |
| 50 | 280.85 | 1167.6 | 250.2 | 917.4 | 0.1188 | 8.418 | 1.0225 | 50 |
| 55 | 286.89 | 1169.4 | 256.3 | 913.1 | 0.1299 | 7.698 | 1.0245 | 55 |
| 60 | 292.51 | 1171.2 | 261.9 | 909.3 | 0.1409 | 7.097 | 1.0263 | 60 |
| 65 | 297.77 | 1172.7 | 267.2 | 905.5 | 0.1519 | 6.583 | 1.0280 | 65 |
| 70 | 302.71 | 1174.3 | 272.2 | 902.1 | 0.1628 | 6.143 | 1.0295 | 70 |
| 75 | 307.38 | 1175.7 | 276.9 | 898.8 | 0.1736 | 5.760 | 1.0309 | 75 |
| 80 | 311.80 | 1177.0 | 281.4 | 895.6 | 0.1843 | 5.426 | 1.0323 | 80 |
| 85 | 316.02 | 1178.3 | 285.8 | 892.5 | 0.1951 | 5.126 | 1.0337 | 85 |
| 90 | 320.04 | 1179.6 | 290.0 | 889.6 | 0.2058 | 4.859 | 1.0350 | 90 |
| 95 | 323.89 | 1180.7 | 294.0 | 886.7 | 0.2165 | 4.619 | 1.0362 | 95 |
| 100 | 327.58 | 1181.9 | 297.9 | 884.0 | 0.2271 | 4.403 | 1.0374 | 100 |
| 105 | 331.13 | 1182.9 | 301.6 | 881.3 | 0.2378 | 4.205 | 1.0385 | 105 |
| 110 | 334.56 | 1184.0 | 305.2 | 878.8 | 0.2484 | 4.026 | 1.0396 | 110 |
| 115 | 337.86 | 1185.0 | 308.7 | 876.3 | 0.2589 | 3.862 | 1.0406 | 115 |
| 120 | 341.05 | 1186.0 | 312.0 | 874.0 | 0.2695 | 3.711 | 1.0416 | 120 |
| 125 | 344.13 | 1186.9 | 315.2 | 871.7 | 0.2800 | 3.571 | 1.0426 | 125 |
| 130 | 347.12 | 1187.8 | 318.4 | 869.4 | 0.2904 | 3.444 | 1.0435 | 130 |
| 140 | 352.85 | 1189.5 | 324.4 | 865.1 | 0.3113 | 3.212 | 1.0453 | 140 |
| 150 | 358.26 | 1191.2 | 330.0 | 861.2 | 0.3321 | 3.011 | 1.0470 | 150 |
| 160 | 363.40 | 1192.8 | 335.4 | 857.4 | 0.3530 | 2.833 | 1.0486 | 160 |
| 170 | 368.29 | 1194.3 | 340.5 | 853.8 | 0.3737 | 2.676 | 1.0502 | 170 |
| 180 | 372.97 | 1195.7 | 345.4 | 850.3 | 0.3945 | 2.535 | 1.0517 | 180 |
| 190 | 377.44 | 1197.1 | 350.1 | 847.0 | 0.4153 | 2.408 | 1.0531 | 190 |
| 200 | 381.73 | 1198.4 | 354.6 | 843.8 | 0.4359 | 2.294 | 1.0545 | 200 |
| 225 | 391.79 | 1201.4 | 365.1 | 836.3 | 0.4876 | 2.051 | 1.0576 | 225 |
| 250 | 400.99 | 1204.2 | 374.7 | 829.5 | 0.5393 | 1.854 | 1.0605 | 250 |
| 275 | 409.50 | 1206.8 | 383.6 | 823.2 | 0.5913 | 1.691 | 1.0632 | 275 |
| 300 | 417.42 | 1209.3 | 391.9 | 817.4 | 0.644 | 1.553 | 1.0657 | 300 |
| 325 | 424.82 | 1211.5 | 399.6 | 811.9 | 0.696 | 1.437 | 1.0680 | 325 |
| 350 | 431.90 | 1213.7 | 406.9 | 806.8 | 0.748 | 1.337 | 1.0703 | 350 |
| 375 | 438.40 | 1215.7 | 414.2 | 801.5 | 0.800 | 1.250 | 1.0724 | 375 |
| 400 | 445.15 | 1217.7 | 421.4 | 796.3 | 0.853 | 1.172 | 1.0745 | 400 |
| 500 | 466.57 | 1224.2 | 444.3 | 779.9 | 1.065 | .939 | 1.0812 | 500 |

# Superheated Steam

Steam is superheated when its temperature exceeds that of saturated steam at the same pressure, and is produced by the application of heat to saturated steam. Its thermal conductivity is considerably less than that of saturated steam, which explains, to a certain degree, the rapid deterioration of superheaters. Before superheated steam can condense between boilers and engine, it must first lose all its superheat and be reduced to saturated steam. If the steam is sufficiently superheated, as with the Manning type of boiler, it can lose a considerable amount of heat by radiation and still reach the engine perfectly dry.

The largest per cent. of waste in an engine is caused by cylinder condensation. The heat necessary to warm the cylinder walls, cooled by the temperature of the exhaust, to the temperature of the entering steam, can only be supplied from the steam itself. Hence, from boilers which produce wet steam, such as the water tube types, unless equipped with special superheaters, there must be considerable condensation. This amount from single non-condensing engines often reaches 30% of the total weight of steam entering the cylinder. It is obvious, however, that if the entering steam is sufficiently superheated, the amount of heat necessary to warm the cylinder could be supplied without producing condensation. This fact explains the high efficiency of steam engines when superheated steam is furnished.

There have been a number of superheaters placed on the market in recent years, but none of them have proven satisfactory, principally on account of their rapid deterioration and the net loss of fuel resulting from their use. Most of these superheaters have been applied to water tube boilers, on account of the large per cent. of moisture always present in the steam. This entrainment often reaches the astonishing figure of 3%; whereas, in well-designed horizontal tubular boilers, the moisture is hardly noticeable, and in the Manning boiler, the steam is always superheated from 25° to 50°.

The following table, compiled from various tests, shows the net fuel loss, as well as the extra cost per horse power, per year, in obtaining the various degrees of superheat by means of a separate superheater:

| Degrees Superheat. | Extra Cost Per Horse Power Per Year. | Net Fuel Loss. |
|---|---|---|
| 25 | $1.25 | 5% |
| 50 | 1.75 | 7% |
| 75 | 2.50 | 10% |
| 100 | 3.75 | 14% |

The above figures explain why the Manning boiler, which produces steam superheated to a high degree, is so economical.

From an admirable test made by E. D. Densmore, on an upright boiler with 17′ tubes (see next page), it appears that the superheat in this type of boiler is influenced by the following conditions: 1st, total superheating surface; 2nd, temperature of fire and flue gases; 3rd, rate of evaporation; 4th, the pressure at which boiler is run; 5th, distance of water line below upper tube sheet. It is the opinion of Mr. Densmore that, if the boiler were run at its full rating, the super-

heat would be greater at the different water levels than the amounts shown on the test, which were taken with the water line dropping.

The object of this test was to discover the amount of superheat present in an upright boiler when carrying the water at different levels.

The diameter of the boiler was 86″, diameter of furnace 78″, height of furnace 57″, number of 2½″ tubes 250, length of tubes 17′, capacity of boiler 200 horse power. Extra gauge glasses were placed on boiler to enable the water line to be followed over a wide range.

The general method of the test was to fill the boiler with water to a point about 3′ below the upper tube sheet, and then, by stopping the feed pump, allow the water to evaporate, thus gradually lowering the water line to about an 8′ level. Observations were taken every five minutes, of the pressure and temperature in the steam main, about 6 from the boiler, the temperature in the smoke box, and the water line.

## Test on Upright Boiler for Superheat

| Time | Corrected pressure in steam main. Pounds | Temp. degrees F in steam main | Temp. degrees F. saturated steam | Superheat, degrees F. | Temp. flue gases, degrees F. | Water level below upper tube sheet. Feet and inches | Change in water level in five minutes. Inches | Pounds of water evaporated in five minutes | Horse power |
|---|---|---|---|---|---|---|---|---|---|
| 2.10 | 95.5 | 358 | 335 | **23** | 465 | 3-3¾ | | | |
| 2.15 | 96. | 358 | 335 | **23** | 471 | 3-6½ | 2¾ | 393.5 | 126. |
| 2.20 | 97.5 | 359 | 336 | **23** | 469.5 | 3-9 | 2½ | 357.5 | 114.5 |
| 2.25 | 95.5 | 361 | 335 | **26** | 481 | 4-2½ | 2½ | 357.5 | 126.1 |
| 2.30 | 94. | 360 | 334 | **26** | 463 | 4-6¼ | 2¾ | 393.5 | 114.6 |
| 2.35 | 96.5 | 362 | 335 | **27** | 456.5 | 4-8¾ | 2½ | 357.5 | 114.6 |
| 2.40 | 98 | 367 | 336 | **31** | 484 | 5-0 | 3¼ | 464.8 | 149.1 |
| 2.45 | 94 | 366 | 334 | **32** | 467.5 | 5-2¾ | 2¾ | 393.5 | 126.5 |
| 2.50 | 95 | 366 | 334 | **32** | 454 | 5-5¼ | 2½ | 357.5 | 115.1 |
| 2.55 | 99 | 371 | 337 | **34** | 477 | 5-7½ | 2¼ | 321.8 | 103.4 |
| 3.00 | 96.5 | 374 | 335 | **39** | 466.5 | 5-10½ | 3 | 429 | 138.2 |
| 3.05 | 98 | 376 | 336 | **40** | 464.5 | 6-1¼ | 2¾ | 393.5 | 127.0 |
| 3.10 | 96 | 376 | 335 | **41** | 450 | 6-3¾ | 2½ | 357.5 | 121.3 |
| 3.15 | 98.5 | 382 | 337 | **45** | 504 | 6-7½ | 2¾ | 393.5 | 126.1 |
| 3.20 | 96 | 388 | 335 | **53** | 486.5 | 6-10½ | 3 | 429 | 139.1 |
| 3.25 | 97.5 | 395 | 336 | **59** | 498 | 7-1¼ | 2¾ | 393.5 | 128.3 |
| 3.30 | 97 | 398 | 336 | **62** | 487.5 | 7-4¼ | 3 | 429 | 140.1 |
| 3.35 | 95.5 | 400 | 335 | **65** | 502.5 | 7-7¼ | 3 | 429 | 140.4 |
| 3.40 | 95.5 | 404 | 335 | **69** | 499 | 7-9¾ | 2½ | 357.5 | 117.3 |
| 3.45 | 95 | 413 | 334 | **79** | 502 | 8-0½ | 2¾ | 393.5 | 128.0 |
| Avg. | 96.3 | | | | | | | | 126.1 |

# Impurities in Boiler Feed Water

All boiler feed waters contain a certain percentage of foreign substances, either in suspension or solution, and while analysis may show only a few grains of solid matter per gallon, the amount of residue from the water evaporated each day is considerable. In the comparatively pure feed waters in most of our New England cities, this amount is seldom less than 1 pound in a 100 horse power boiler, while in some localities, it is more than 50 pounds. An excessive amount of impurities causes the formation of scale in a boiler, which results in a loss of fuel, and leads to extensive repairs. It is estimated that the presence of 1/16 of an inch of hard scale reduces the efficiency of a boiler 10 per cent. The following information in regard to corrosion and impurities will be found interesting.

Air is composed of one part oxygen and four parts nitrogen, but dissolved in water, the percentage, owing to the greater solubility of oxygen, is about one-half. When liberated by boiling, there is a large excess of oxygen in the air, which is chemically very active, and corrosion takes place in the form of pitting. It has been found by experimenting that the liberated air is most active at a comparatively low temperature, which explains why corrosion is so prevalent in feed pipes, heating boilers, and boilers where the circulation is poor. When free acid is present in feed waters, or when liberated in the boiler by chemical action, pitting or corrosion follows.

Electrolysis, or galvanic action, often takes place in a boiler when the feed water has passed through brass pipe, and deep pitting of the tubes or plates results in a very short space of time. Chemical analysis will show traces of copper deposited where the pitting occurs. The constant use of soda ash to render the feed water alkaline, will prevent this trouble to a great extent.

By far the most dangerous impurity in feed water is grease or oil, the merest trace (.001 of an inch in thickness) of which will cause far more trouble than one-eighth inch of boiler scale. If the feed water is taken from a hot well or an open heater, the oil should be completely removed before it enters the boiler.

The following table shows how impure feed waters may be treated:

## EFFECT OF, AND CORRECTIVES FOR, IMPURITIES IN FEED WATER

| Troublesome Substance | Trouble | Remedy or Palliation |
|---|---|---|
| Sediment, mud, clay, etc. | Incrustation | Filtration. Blowing off. |
| Readily soluble salts | Incrustation | Blowing off. |
| Bicarbonates of lime, magnesia, iron | Incrustation | Heating feed. Addition of caustic soda, lime, magnesia |
| Sulphate of lime | Incrustation | Addition of carbonate of soda, barium chloride. |
| Chloride and sulphate of magnesium | Corrosion | Addition of carbonate of soda. |
| Carbonate of soda in large amounts | Priming* | Addition of barium chloride. |
| Acid | Corrosion | Alkali. |
| Dissolved carbonic acid and oxygen | Corrosion | Heating feed. Addition of caustic soda or slacked lime. |
| Grease (from condensed water) | Corrosion | Slacked lime and filtering. Carbonate of soda. Substitute mineral oil. |
| Organic matter (sewage) | Priming | Precipitate with alum or ferric chloride and filter. |
| Organic matter | Corrosion | Precipitate with alum or ferric chloride and filter. |

*Similar result is caused by carbonates of calcium and magnesium.

# Heating Buildings by Steam

In heating buildings by steam, the size of boiler and amount of heating surface required depend largely upon the kind of building, its location, and the following conditions: whether the building is protected or isolated; whether built of brick, stone or wood; the amount of glass and outside wall surface; and also largely upon exposure of rooms. Without this information, it is impossible to correctly estimate the amount of radiator surface. We give below results obtained by averaging the different existing conditions.

| | One Sq. Ft. Radiating Surface Heats | |
|---|---|---|
| | Low Pressure Steam. Cubic Feet. | Hot Water. Cubic Feet. |
| Living rooms with three exposures and large amount of glass, | 40 | 20 to 25 |
| Living rooms with two exposures and ordinary amount of glass, | 50 | 25 to 30 |
| Living rooms with one exposure and ordinary windows, | 60 | 30 to 35 |
| Halls located on corner, | 55 | 30 to 33 |
| Halls located in center of house, | 70 | 35 to 40 |
| Bath and small exposed rooms, | 40 | 20 to 25 |
| Sleeping rooms, | 60 to 70 | 25 to 35 |
| School rooms, | 60 to 80 | 30 to 50 |
| Churches and auditoriums, | 75 to 125 | 80 to 100 |
| Offices, | 60 to 80 | 30 to 50 |
| Stores, | 70 to 100 | 40 to 70 |
| Theatres, | 200 to 300 | |

The foregoing figures are based on zero weather. If extreme temperature is above zero, less radiating surface may be used, and if below, the radiators should be increased.

For indirect radiators, add at least 50% to the above ratings. For direct indirect, add 25%.

One square foot of heating surface in boiler will supply from 7 to 10 square feet radiating surface, depending upon the size of boiler and the efficiency of its heating surface, as well as that of the radiating surface. One boiler horse power will supply from 240′ to 360′ of 1″ steam pipe, or 80 to 120 square feet of radiating surface. Under ordinary conditions, one horse power will heat, approximately, in

| | Cubic Feet. |
|---|---|
| Brick dwellings, in blocks, as in cities, | 15,000 to 20,000 |
| " stores, in blocks, | 10,000 to 15,000 |
| " dwellings, exposed all round, | 10,000 to 15,000 |
| " mills, shops, factories, etc., | 7,000 to 10,000 |
| Wooden dwellings, exposed, | 7,000 to 10,000 |
| Foundries and wooden shops, | 6,000 to 10,000 |
| Exhibition buildings, largely glass, etc., | 4,000 to 15,000 |

The system of heating mills and manufacturing plants by means of pipes placed overhead is being largely adopted in preference to radiators near the floor, particularly for rooms in which there are shafting and belting to circulate the air.

In heating buildings, care should be taken to supply the necessary moisture to keep the air from being dry and uncomfortable. The capacity of air for moisture rises rapidly as it is heated, it being four times greater at 72° than at 32°. For comfort, air should be kept at about 50% saturated. This would require one pound of vapor to be added to each 2500 cubic feet heated from 32° to 70°.

## NUMBER OF U. S. GALLONS IN ROUND TANKS

**FOR ONE FOOT IN DEPTH.**

| Dia. of tanks. Ft. In. | No. U. S. gals. | Cubic ft. and area in sq. ft. | Dia. of tanks. Ft. In. | No. U. S. gals. | Cubic ft. and area in sq. ft. | Dia. of tanks. Ft. In. | No. U. S. gals. | Cubic ft. and area in sq. ft. | Dia. of tanks. Ft. In. | No. U. S. gals. | Cubic ft. and area in sq. ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.87 | .785 | 3 | 52.88 | 7.069 | 5 | 146.88 | 19.63 | 9 | 475.89 | 63.62 |
| 1-1 | 6.89 | .922 | 3-1 | 55.86 | 7.467 | 5-1 | 151.82 | 20.29 | 9-3 | 502.70 | 67.20 |
| 1-2 | 8. | 1.069 | 3-2 | 58.92 | 7.876 | 5-2 | 156.83 | 20.97 | 9-6 | 530.24 | 70.88 |
| 1-3 | 9.18 | 1.227 | 3-3 | 62.06 | 8.296 | 5-3 | 161.93 | 21.65 | 9-9 | 558.51 | 74.66 |
| 1-4 | 10.44 | 1.396 | 3-4 | 65.28 | 8.727 | 5-4 | 167.12 | 22.34 | 10 | 587.52 | 78.54 |
| 1-5 | 11.79 | 1.576 | 3-5 | 68.58 | 9.168 | 5-5 | 172.38 | 23.04 | 10-3 | 617.26 | 82.52 |
| 1-6 | 13.22 | 1.767 | 3-6 | 71.97 | 9.621 | 5-6 | 177.72 | 23.76 | 10-6 | 640.74 | 86.59 |
| 1-7 | 14.73 | 1.969 | 3-7 | 75.44 | 10.085 | 5-7 | 183.15 | 24.48 | 10-9 | 678.95 | 90.76 |
| 1-8 | 16.32 | 2.182 | 3-8 | 78.99 | 10.559 | 5-8 | 188.66 | 25.22 | 11 | 710.90 | 95.03 |
| 1-9 | 17.99 | 2.405 | 3-9 | 82.62 | 11.045 | 5-9 | 194.25 | 25.97 | 11-3 | 743.58 | 99.40 |
| 1-10 | 19.75 | 2.640 | 3-10 | 86.33 | 11.541 | 5-10 | 199.92 | 26.73 | 11-6 | 776.99 | 103.87 |
| 1-11 | 21.58 | 2.885 | 3-11 | 90.13 | 12.048 | 5-11 | 205.67 | 27.49 | 11-9 | 811.14 | 108.43 |
| 2 | 23.50 | 3.142 | 4 | 94. | 12.566 | 6 | 211.51 | 28.27 | 12 | 846.03 | 113.10 |
| 2-1 | 25.50 | 3.409 | 4-1 | 97.96 | 13.095 | 6-3 | 229.50 | 30.68 | 12-3 | 881.65 | 117.86 |
| 2-2 | 27.58 | 3.687 | 4-2 | 102. | 13.635 | 6-6 | 248.23 | 33.18 | 12-6 | 918. | 122.72 |
| 2-3 | 29.74 | 3.976 | 4-3 | 106.12 | 14.186 | 6-9 | 267.69 | 35.78 | 12-9 | 955.09 | 127.68 |
| 2-4 | 31.99 | 4.276 | 4-4 | 110.32 | 14.748 | 7 | 287.88 | 38.48 | 13 | 992.91 | 132.73 |
| 2-5 | 34.31 | 4.587 | 4-5 | 114.61 | 15.321 | 7-3 | 308.81 | 41.28 | 13-3 | 1031.50 | 137.89 |
| 2-6 | 36.72 | 4.909 | 4-6 | 118.97 | 15.90 | 7-6 | 330.48 | 44.18 | 13-6 | 1070.80 | 143.14 |
| 2-7 | 39.21 | 5.241 | 4-7 | 123.42 | 16.50 | 7-9 | 352.88 | 47.17 | 13-9 | 1110.80 | 148.49 |
| 2-8 | 41.78 | 5.585 | 4-8 | 127.95 | 17.10 | 8 | 376.01 | 50.27 | 14 | 1151.50 | 153.94 |
| 2-9 | 44.43 | 5.940 | 4-9 | 132.56 | 17.72 | 8-3 | 399.88 | 53.46 | 14-3 | 1193. | 159.48 |
| 2-10 | 47.16 | 6.305 | 4-10 | 137.25 | 18.35 | 8-6 | 424.48 | 56.75 | 14-6 | 1235.30 | 165.13 |
| 2-11 | 49.98 | 6.681 | 4-11 | 142.02 | 18.99 | 8-9 | 449.82 | 60.13 | 14-9 | 1278.20 | 170.87 |
| | | | | | | | | | 15 | 1321.90 | 176.71 |

**31 1-2 Gallons equals 1 Barrel.**

To find the capacity of tanks greater than the largest given in the table, look in the table for a Tank one-half of the given size and multiply its capacity by 4, or one of one-third its size and multiply its capacity by 9, etc.

## NUMBER OF U. S. GALLONS IN RECTANGULAR TANKS

**FOR ONE FOOT IN DEPTH.**

| Width of tank. Ft. In. | Length of Tank. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ft. 2 | Ft. 3 | Ft. 4 | Ft. 5 | Ft. 6 | Ft. 7 | Ft. 8 | Ft. 9 | Ft. 10 | Ft. 11 | Ft. 12 |
| 2 | 29.92 | 44.88 | 59.84 | 74.81 | 89.77 | 104.73 | 119.69 | 134.65 | 149.61 | 164.57 | 179.53 |
| 2-6 | | 56.10 | 74.80 | 93.51 | 112.21 | 130.91 | 149.61 | 168.31 | 187.01 | 205.71 | 224.41 |
| 3 | | 67.32 | 89.77 | 112.21 | 134.65 | 157.09 | 179.53 | 202.97 | 224.41 | 246.86 | 269.30 |
| 3-6 | | | 104.73 | 130.91 | 157.09 | 183.27 | 209.45 | 235.63 | 261.82 | 288.00 | 314.18 |
| 4 | | | 119.69 | 149.61 | 179.53 | 209.45 | 239.37 | 269.30 | 299.22 | 329.14 | 359.06 |
| 4-6 | | | | 168.31 | 201.97 | 255.63 | 269.30 | 302.96 | 336.62 | 370.28 | 403.94 |
| 5 | | | | 187.01 | 224.41 | 261.82 | 299.22 | 336.62 | 374.03 | 411.43 | 448.83 |
| 5-6 | | | | | 246.86 | 288.00 | 329.14 | 370.28 | 411.43 | 452.57 | 493.71 |
| 6 | | | | | 269.30 | 314.18 | 359.06 | 403.94 | 448.83 | 493.71 | 538.59 |
| 6-6 | | | | | | 340.36 | 388.98 | 437.60 | 486.23 | 534.85 | 583.47 |
| 7 | | | | | | 366.54 | 418.91 | 471.27 | 523.64 | 575.99 | 628.36 |
| 7-6 | | | | | | | 448.83 | 504.93 | 561.04 | 617.14 | 673.24 |
| 8 | | | | | | | 478.75 | 538.59 | 598.44 | 658.28 | 718.12 |
| 8-6 | | | | | | | | 572.25 | 635.84 | 699.42 | 763.00 |
| 9 | | | | | | | | 605.92 | 673.25 | 740.56 | 807.89 |
| 9-6 | | | | | | | | | 710.65 | 781.71 | 852.77 |
| 10 | | | | | | | | | 748.05 | 822.86 | 897.66 |
| 10-6 | | | | | | | | | | 864.00 | 942.56 |
| 11 | | | | | | | | | | 905.14 | 987.43 |
| 11-6 | | | | | | | | | | | 1032.3 |
| 12 | | | | | | | | | | | 1077.2 |

## STANDARD SIZES, ETC., OF LAP-WELDED CHARCOAL-IRON BOILER-TUBES.

(National Tube Works.)

| External diameter | Internal diameter | Standard thickness | Internal circumference | External circumference | Internal area | | External area | | Length of tube per sq. ft. of inside surface | Length of tube per sq. ft. of outside surface | Length of tube per sq. ft. of mean surface | Weight per lineal foot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In. | In. | In. | In. | In. | Sq. In. | Sq. Ft. | Sq. In. | Sq. Ft. | Ft. | Ft. | Ft. | Lbs. |
| 1 | .810 | .095 | 2.545 | 3.142 | .515 | .0036 | .785 | .0055 | 4.479 | 3.820 | 4.149 | .90 |
| 1¼ | 1.060 | .095 | 3.330 | 3.927 | .882 | .0061 | 1.227 | .0085 | 3.604 | 3.056 | 3.330 | 1.15 |
| 1½ | 1.310 | .095 | 4.115 | 4.712 | 1.348 | .0094 | 1.767 | .0123 | 2.916 | 2.547 | 2.732 | 1.40 |
| 1¾ | 1.560 | .095 | 4.901 | 5.498 | 1.911 | .0133 | 2.405 | .0167 | 2.448 | 2.183 | 2.316 | 1.65 |
| 2 | 1.810 | .095 | 5.686 | 6.283 | 2.573 | .0179 | 3.142 | .0218 | 2.110 | 1.910 | 2.010 | 1.91 |
| 2¼ | 2.060 | .095 | 6.472 | 7.069 | 3.333 | .0231 | 3.976 | .0276 | 1.854 | 1.698 | 1.776 | 2.16 |
| 2½ | 2.282 | .109 | 7.169 | 7.854 | 4.090 | .0284 | 4.909 | .0341 | 1.674 | 1.528 | 1.601 | 2.75 |
| 2¾ | 2.532 | .109 | 7.955 | 8.639 | 5.035 | .0350 | 5.940 | .0412 | 1.508 | 1.389 | 1.449 | 3.04 |
| 3 | 2.782 | .109 | 8.740 | 9.425 | 6.079 | .0422 | 7.069 | .0491 | 1.373 | 1.273 | 1.322 | 3.33 |
| 3¼ | 3.010 | .120 | 9.456 | 10.210 | 7.116 | .0494 | 8.296 | .0576 | 1.269 | 1.175 | 1.222 | 3.96 |
| 3½ | 3.260 | .120 | 10.242 | 10.996 | 8.347 | .0580 | 9.621 | .0668 | 1.172 | 1.091 | 1.132 | 4.28 |
| 3¾ | 3.510 | .120 | 11.027 | 11.781 | 9.676 | .0672 | 11.045 | .0767 | 1.088 | 1.019 | 1.054 | 4.60 |
| 4 | 3.732 | .134 | 11.724 | 12.566 | 10.939 | .0760 | 12.566 | .0873 | 1.024 | .955 | .990 | 5.47 |
| 4½ | 4.232 | .134 | 13.295 | 14.137 | 14.066 | .0977 | 15.904 | .1104 | .903 | .849 | .876 | 6.17 |
| 5 | 4.704 | .148 | 14.778 | 15.708 | 17.379 | .1207 | 19.635 | .1364 | .812 | .764 | .788 | 7.58 |

## TABLE OF EQUATION OF PIPES

STANDARD STEAM AND GAS PIPES.

| Dia. | 1 | 1½ | 2 | 2½ | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Dia. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ½ | 4 .88 | 15.8 | 31.7 | 52.9 | 96.9 | 205 | 377 | 620 | 918 | 1,292 | 1,767 | 2,488 | 3,014 | 3,786 | ½ |
| ¾ | 2.05 | 6.97 | 14.0 | 23.3 | 42.5 | 90.4 | 166 | 273 | 405 | 569 | 779 | 1,096 | 1,328 | 1,668 | ¾ |
| 1 | | 3.45 | 6.82 | 11.4 | 20.9 | 44.1 | 81.1 | 133 | 198 | 278 | 380 | 536 | 649 | 815 | 1 |
| 1½ | 3.20 | | 2.00 | 3.34 | 6.13 | 13.0 | 23.8 | 39.2 | 58.1 | 81.7 | 112 | 157 | 190 | 239 | 1½ |
| 2 | 7.25 | 2.26 | | 1.67 | 3.06 | 6.47 | 11.9 | 19.6 | 29.0 | 40.8 | 55.8 | 78.5 | 95.1 | 119 | 2 |
| 2½ | 13.6 | 4.23 | 1.87 | | 1.83 | 3.87 | 7.12 | 11 7 | 17.4 | 24.4 | 33.4 | 47.0 | 56.9 | 71.5 | 2½ |
| 3 | 22.6 | 7.03 | 3.11 | 1.66 | | 2.12 | 3.89 | 6.39 | 9.48 | 13.3 | 20.9 | 23.7 | 31.2 | 39.1 | 3 |
| 4 | 49.8 | 15.5 | 6.87 | 3.67 | 2.21 | | 1.84 | 3.02 | 4.48 | 6.30 | 8.61 | 12.1 | 14.7 | 18.5 | 4 |
| 5 | 90.9 | 28.3 | 12.5 | 6.70 | 4.03 | 1.83 | | 1.65 | 2.44 | 3.43 | 4.69 | 6.60 | 8.00 | 10.0 | 5 |
| 6 | 148 | 46.0 | 20.4 | 10.9 | 6.56 | 2.97 | 1.63 | | 1.48 | 2.09 | 2.85 | 4.02 | 4.86 | 6.11 | 6 |
| 7 | 226 | 70.5 | 31.2 | 16.6 | 10.0 | 4.54 | 2.49 | 1.51 | | 1.41 | 1.93 | 2.71 | 3.28 | 4.12 | 7 |
| 8 | 322 | 101 | 44.5 | 23.8 | 14.3 | 6.48 | 3.54 | 2.18 | 1.43 | | 1.35 | 1.93 | 2.33 | 2.92 | 8 |
| 9 | 440 | 137 | 60.8 | 32.5 | 19.5 | 8.85 | 4.85 | 2.98 | 1.95 | 1.37 | | 1.41 | 1.71 | 2.14 | 9 |
| 10 | 582 | 181 | 80.4 | 42.9 | 25.8 | 11.7 | 6.40 | 3.93 | 2.57 | 1.80 | 1.32 | | 1.21 | 1.52 | 10 |
| 11 | 747 | 233 | 103 | 55.1 | 33.1 | 15.0 | 8.22 | 5.05 | 3.31 | 2.32 | 1.70 | 1.28 | | 1.26 | 11 |
| 12 | 938 | 293 | 129 | 69.2 | 41.6 | 18.8 | 10.3 | 6.34 | 4.15 | 2.91 | 2.13 | 1.61 | 1.26 | | 12 |
| 13 | 1,146 | 358 | 158 | 84.5 | 50.7 | 23.0 | 12.6 | 7.75 | 5.07 | 3.56 | 2.60 | 1.98 | 1.53 | 1.22 | 13 |
| 14 | 1,403 | 438 | 193 | 103 | 62.2 | 28 2 | 15.4 | 9.48 | 6.21 | 4.35 | 3.18 | 2.41 | 1.88 | 1.50 | 14 |
| 15 | 1,698 | 530 | 234 | 125 | 75.3 | 34.1 | 18.7 | 11.5 | 7.52 | 5.27 | 3.85 | 2.92 | 2.27 | 1.81 | 15 |
| 16 | 1,984 | 619 | 274 | 146 | 88.0 | 39.9 | 21.8 | 13.4 | 8.78 | 6.15 | 4.51 | 3.41 | 2.66 | 2.12 | 16 |
| 17 | 2,322 | 724 | 320 | 171 | 103 | 46.6 | 25.6 | 15.7 | 10.3 | 7.20 | 5.27 | 3.99 | 3.11 | 2.47 | 17 |
| 18 | 2,691 | 840 | 371 | 198 | 119 | 54.1 | 29.6 | 18.2 | 11.9 | 8.35 | 6.11 | 4.63 | 3.60 | 2.87 | 18 |
| 20 | 3,532 | 1,102 | 487 | 260 | 157 | 70.9 | 38.9 | 23.9 | 15.6 | 10.9 | 8.02 | 6.07 | 4.73 | 3.76 | 20 |
| 24 | 5,644 | 1,761 | 778 | 416 | 250 | 113 | 62.1 | 38.2 | 25.0 | 17.5 | 12.8 | 9.70 | 7.55 | 6.01 | 24 |

ACTUAL INTERNAL DIAMETERS.

# SCHEDULE OF STANDARD FLANGES FOR EXTRA HEAVY IRON PIPE, FITTINGS AND VALVES

(As adopted June 28, 1901, at a meeting of valve and fitting manufacturers of the United States. Pressure 125 to 250 lbs. per square inch.)

**DRILLING SHOULD STRADDLE VERTICAL AXIS.**

| Size of port. Inches. | For wrought-iron pipe. Inches. | For cast-iron pipe. Inches. | Diameter of flanges. Inches. | Thickness of flanges. Inches. | Diameter of bolt circle. Inches. | Number of bolts. | Size of bolts. Inches. | Size of gasket, copper or rubber. Inches. |
|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 2 | 6½ | ⅞ | 5 | 4 | ⅝ x 2½ | 2½ x 4¼ |
| 2½ | 2½ | 2½ | 7½ | 1 | 5⅞ | 4 | ¾ x 3 | 3 x 5 |
| 3 | 3 | 3 | 8¼ | 1⅛ | 6⅝ | 8 | ⅝ x 3 | 3½ x 5⅞ |
| 3½ | 3½ | 3½ | 9 | 1 3/16 | 7¼ | 8 | ⅝ x 3 | 4 x 6⅝ |
| 4 | 4 | 4 | 10 | 1¼ | 7⅞ | 8 | ¾ x 3½ | 4½ x 7⅛ |
| 4½ | 4½ | 4½ | 10½ | 1 5/16 | 8½ | 8 | ¾ x 3½ | 5 x 7¾ |
| 5 | 5 | 5 | 11 | 1⅜ | 9¼ | 8 | ¾ x 3¾ | 5½ x 8½ |
| 6 | 6 | 6 | 12½ | 1 7/16 | 10⅝ | 12 | ¾ x 3¾ | 6½ x 9⅞ |
| 7 | 7 | 7 | 14 | 1½ | 11⅞ | 12 | ⅞ x 4 | 7½ x 11 |
| 8 | 8 | 8 | 15 | 1⅝ | 13 | 12 | ⅞ x 4¼ | 8½ x 12 |
| 9 | 9 | 9 | 16 | 1¾ | 14 | 12 | ⅞ x 4½ | 9½ x 13 |
| 10 | 10 | 10 | 17½ | 1⅞ | 15¼ | 16 | ⅞ x 4¾ | 10½ x 14⅓ |
| 12 | 12 | 12 | 20 | 2 | 17¾ | 16 | ⅞ x 5 | 12¾ x 16¾ |
| 14 | 15 | 14 | 22½ | 2⅛ | 20 | 20 | ⅞ x 5¼ | 14 x 19 |
| 15 | 16 | 15 | 23½ | 2 3/16 | 21 | 20 | 1 x 5½ | 15 x 20 |
| 16 | 17 | 16 | 25 | 2¼ | 22½ | 20 | 1 x 5¾ | 16 x 21½ |
| 18 | 18 | 18 | 27 | 2⅜ | 24½ | 24 | 1 x 6 | 18 x 23½ |
| 20 | 20/21 | 20 | 29½ | 2½ | 26¾ | 24 | 1⅛ x 6¼ | 20 x 25½ |
| 22 | 22 | 22 | 31½ | 2⅝ | 28¾ | 28 | 1⅛ x 6½ | 22 x 27½ |
| 24 | 24 | 24 | 34 | 2¾ | 31¼ | 28 | 1⅛ x 6¾ | 24 x 30 |

Outside diameter.

The bolt circle diameters as above stated will allow the use of a calking recess on pipe flanges, provided such device is specified. Flanges, flanged fittings, valves, etc., are drilled in multiples of four, so that fittings may be made to face in any quarter and holes straddle center line.

## SIZE OF CHIMNEYS FOR POWER PLANTS

**BURNING FOUR POUNDS OF COAL PER HORSE POWER PER HOUR.***

| Diam. | Area | Height of Chimney in Feet. | | | | | | | | | | | | | | Equiv. side of sq. c'my |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In. | Sq. Ft. | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 125 | 150 | 175 | 200 | 225 | 250 | 300 | |
| 18 | 1.77 | 42 | 46 | 49 | 52 | | | | | | | | | | | 16 |
| 21 | 2.41 | 55 | 62 | 65 | 68 | | | | | | | | | | | 19 |
| 24 | 3.14 | 72 | 78 | 85 | 91 | 98 | | | | | | | | | | 22 |
| 27 | 3.98 | 91 | 101 | 107 | 114 | 124 | | | | | | | | | | 24 |
| 30 | 4.91 | 114 | 124 | 133 | 143 | 153 | 159 | | | | | | | | | 27 |
| 33 | 5.94 | | 149 | 163 | 172 | 182 | 192 | 202 | | | | | | | | 30 |
| 36 | 7.07 | | 179 | 192 | 205 | 218 | 228 | 241 | 257 | | | | | | | 32 |
| 39 | 8.30 | | | 224 | 241 | 257 | 270 | 283 | 302 | | | | | | | 35 |
| 42 | 9.62 | | | 263 | 282 | 296 | 312 | 332 | 351 | 390 | | | | | | 38 |
| 48 | 12.57 | | | | 364 | 387 | 410 | 429 | 458 | 510 | | | | | | 43 |
| 54 | 15.90 | | | | | 491 | 517 | 543 | 579 | 647 | 683 | | | | | 48 |
| 60 | 19.64 | | | | | 605 | 637 | 669 | 715 | 797 | 845 | | | | | 54 |
| 66 | 23.76 | | | | | | 774 | 809 | 865 | 965 | 1021 | 1092 | | | | 59 |
| 72 | 28.27 | | | | | | 920 | 962 | 1051 | 1147 | 1215 | 1300 | 1378 | | | 64 |
| 78 | 33.18 | | | | | | | 1131 | 1206 | 1349 | 1459 | 1524 | 1619 | 1706 | | 70 |
| 84 | 38.48 | | | | | | | 1310 | 1401 | 1563 | 1654 | 1768 | 1875 | 1976 | 2165 | 75 |
| 90 | 44.18 | | | | | | | | 1609 | 1794 | 1898 | 2031 | 2155 | 2269 | 2486 | 80 |
| 96 | 50.27 | | | | | | | | 1830 | 2041 | 2161 | 2311 | 2451 | 2584 | 2831 | 86 |
| 102 | 56.75 | | | | | | | | 2067 | 2304 | 2434 | 2607 | 2766 | 2915 | 3195 | 91 |
| 108 | 63.62 | | | | | | | | 2314 | 2584 | 2734 | 2935 | 3101 | 3269 | 3578 | 96 |
| 114 | 70.88 | | | | | | | | | 2879 | 3045 | 3257 | 3455 | 3643 | 3991 | 101 |
| 120 | 78.54 | | | | | | | | | 3191 | 3374 | 3611 | 3821 | 4037 | 4420 | 107 |
| 132 | 95.03 | | | | | | | | | 3861 | 4082 | 4368 | 4631 | 4882 | 5350 | 117 |
| 144 | 113.10 | | | | | | | | | 4596 | 4859 | 5200 | 5515 | 5811 | 6367 | 128 |

* From "Chimney Designs and Theory" by William Wallace Christy.
Horse power $= 3.25\ A\ \sqrt{H}$.

A = Area of chimney.
H = Height of chimney.

## SIZE OF CHIMNEYS FOR POWER PLANTS

**BURNING FIVE POUNDS OF COAL PER HORSE POWER PER HOUR.†**

| Diam. | Area | ‡ Effect. Area | Height of Chimney in Feet. | | | | | | | | | | | | | | § Equiv. side of sq. c'my |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In. | Sq. Ft. | Sq. Ft. | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 125 | 150 | 175 | 200 | 225 | 250 | 300 | |
| 18 | 1.77 | .97 | 23 | 25 | 27 | 29 | | | | | | | | | | | 16 |
| 21 | 2.41 | 1.47 | 35 | 38 | 41 | 44 | | | | | | | | | | | 19 |
| 24 | 3.14 | 2.08 | 49 | 54 | 58 | 62 | 66 | | | | | | | | | | 22 |
| 27 | 3.98 | 2.78 | 65 | 72 | 78 | 83 | 88 | | | | | | | | | | 24 |
| 30 | 4.91 | 3.58 | 84 | 92 | 100 | 107 | 113 | 119 | | | | | | | | | 27 |
| 33 | 5.94 | 4.48 | | 115 | 125 | 133 | 141 | 149 | 156 | | | | | | | | 30 |
| 36 | 7.07 | 5.47 | | 141 | 152 | 163 | 173 | 182 | 191 | 204 | | | | | | | 32 |
| 39 | 8.30 | 6.57 | | | 183 | 196 | 208 | 219 | 224 | 245 | 268 | | | | | | 35 |
| 42 | 9.62 | 7.76 | | | 216 | 231 | 245 | 258 | 271 | 289 | 316 | 342 | | | | | 38 |
| 48 | 12.57 | 10.44 | | | | 311 | 330 | 348 | 365 | 389 | 426 | 460 | 492 | | | | 43 |
| 54 | 15.90 | 13.51 | | | | | 427 | 449 | 472 | 503 | 551 | 595 | 636 | 675 | | | 48 |
| 60 | 19.64 | 16.98 | | | | | 536 | 565 | 593 | 632 | 692 | 748 | 800 | 848 | 894 | | 54 |
| 66 | 23.76 | 20.83 | | | | | | 694 | 728 | 776 | 849 | 918 | 981 | 1040 | 1097 | 1201 | 59 |
| 72 | 28.27 | 25.08 | | | | | | 835 | 876 | 934 | 1023 | 1105 | 1181 | 1253 | 1320 | 1447 | 64 |
| 78 | 33.18 | 29.73 | | | | | | | 1038 | 1107 | 1212 | 1310 | 1400 | 1485 | 1565 | 1715 | 70 |
| 84 | 38.48 | 34.76 | | | | | | | 1214 | 1294 | 1418 | 1531 | 1637 | 1736 | 1830 | 2005 | 75 |
| 90 | 44.18 | 40.19 | | | | | | | | 1496 | 1639 | 1770 | 1893 | 2008 | 2116 | 2318 | 80 |
| 96 | 50.27 | 46.01 | | | | | | | | 1712 | 1876 | 2027 | 2167 | 2298 | 2423 | 2654 | 86 |
| 102 | 56.75 | 52.23 | | | | | | | | 1944 | 2130 | 2300 | 2459 | 2609 | 2750 | 3012 | 91 |
| 108 | 63.62 | 58.83 | | | | | | | | 2090 | 2399 | 2592 | 2771 | 2939 | 3098 | 3393 | 96 |

† From Kent's "Mechanical Engineer's Pocket Book."
‡ Effective area "E" $= A - .6\sqrt{A}$.
§ Side of equivalent square chimney $= \sqrt{E} + 4''$.

Horse power $= 3.33\ (A - .6\sqrt{A.})\ \sqrt{H}$.
A = Area of chimney.
H = Height of chimney.

# Rules for Care and Management of Steam Boilers

1. Condition of Water.—The first duty of an engineer when he enters the boiler room in the morning is to ascertain how many gauges of water there are in the boilers. Never unbank or replenish the fires until this is done. Accidents have occurred, and many boilers have been entirely ruined from neglect of this precaution.

2. Low Water.—In case of low water, immediately cover the fire with ashes; or, if no ashes are at hand, use fresh coal. Do not turn on the feed water under any circumstances, nor tamper with the safety-valve. Let the steam outlets remain as they are.

3. In Case of Foaming.—Close throttle, and keep closed long enough to show true level of water. If the level is sufficiently high, feeding and blowing will usually correct the evil. In case of violent foaming, caused by dirty water, in addition to the above, check draught and cover fires with fresh coal.

4. Leaks.—When leaks are discovered, they should be repaired at once.

5. Blowing Off.—Blow down, under a pressure not exceeding ten pounds. Where surface blow-cocks are used, they should be opened wide once a day, oftener if the water contains much sediment.

6. Filling the Boiler.—After blowing down, allow the boiler to become cool before filling again. Cold water pumped into hot boilers is very injurious.

7. Exterior of Boiler.—Care should be taken that no water comes in contact with the exterior of boiler, either from leaky joints or other causes.

8. Removing Deposit and Sediment.—In tubular boilers, the handholes should be often removed, and the plates over the fire thoroughly cleaned. When boilers are fed in front and blown off through the same pipe, the collection of mud or sediment in the rear end should be often removed.

9. Safety-Valves.—Raise the safety-valves cautiously and frequently, as they are liable to become fast in their seats and useless for the purpose intended.

10. Safety-Valves and Pressure Gauge.—Should the gauge at any time indicate the limit of pressure allowed, see that the safety-valves are blowing off.

11. Gauge Cocks. Glass Gauge.—Keep gauge cocks clear and in constant use. Glass gauges should not be relied on altogether.

12. Blisters.—When a blister appears, there must be no delay in having it carefully examined and repaired.

13. Clean Sheets.—Particular care should be taken to keep sheets and parts of boilers exposed to the fire perfectly clean; also all tubes well swept. This is particularly necessary where wood or soft coal is used for fuel.

14. General Care of Boilers and Connections.—Under all circumstances, keep the gauges, cocks, etc., clean and in good order, and things generally about the engine and boiler room in a neat condition.

15. Deposits of Grease.—Deposits of grease are especially dangerous. Great care should be exercised when any of the exhaust returns are introduced to prevent grease deposits adhering to the fire plates, as they are liable to cause serious injury.

16. Idle Boilers.—If boilers are to remain idle any length of time, manhole and handhole plates should be removed and the internal surfaces throughly washed and left dry. External parts should be made clean and dry, to prevent corrosion.

## TEMPERATURE OF FIRE (POUILLET)

| Appearance | Temperature, Degrees F. | Appearance | Temperature, Degrees F. |
|---|---|---|---|
| Red, just visible | 977 | Orange, deep | 2010 |
| Red, dull | 1290 | Orange, clear | 2190 |
| Red, cherry dull | 1470 | White heat | 2370 |
| Red, cherry full | 1650 | White, bright | 2550 |
| Red, cherry clear | 1830 | White, dazzling | 2730 |

## USEFUL INFORMATION

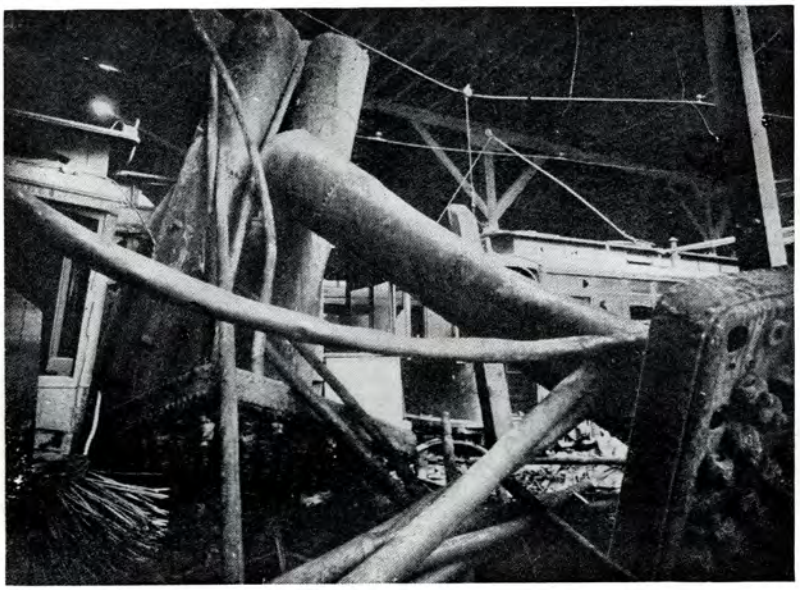
The circumference of a circle = Diameter × 3.1416.
The diameter of a circle = Circumference × .3183.
The area of a circle = Square of diameter × .7854.
Doubling the diameter of a circle increases its area four times.
The side of an equal square = Diameter of circle × .8862.
The diameter of an equal circle = Side of square × 1.128.
The surface of a sphere = Square of diameter × 3.1416
The volume of a sphere = Cube of diameter × .5236.
The volume of a cylinder = Area of one end × length.
The capacity of cylindrical tanks in U. S. gallons = Square of diameter expressed in inches × length in inches × .0034.
One cubic foot of water weighs 62½ pounds, and contains 7½ gallons.
One gallon of water, U. S. standard, weighs 8⅓ pounds.
One barrel = 31½ gallons.
To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet × .434.
The heating surface of a boiler= ½ the surface of the shell + the inside area of all tubes + the water surface of heads.

$$\text{Working pressure} = \frac{\text{Tensile strength} \times \text{thickness of shell} \times \text{seam}}{\text{Radius in inches} \times \text{factor of safety.}}$$

1 H. P. = 746 Watts. = 0.746 K. W.
1 K. W. = 1.34 H. P.

$$\text{Area of segment in square inches} = \frac{4H'}{3}\sqrt{\frac{2R}{H} - .608}$$

H = Distance from tubes to shell, minus 5″.
R = Radius of boiler, minus 3″.
The length of an arc = Number of degrees × diameter × 0.008727.
The area of a sector of a circle = Length of arc × half the radius.
The area of an ellipse = Long diameter × short diameter × 0.7854.
The area of a triangle = Base × half the perpendicular height.



**The above cuts show three disastrous "safety" water tube boiler explosions:**

| | |
|---|---|
| **Property loss** | **$139,000** |
| **Lives lost** | **7** |
| **Injured** | **17** |